185th CAM SQ.
SIOUX CITY, IA

ECM-Shop

HICKOK

MODEL 1604 M

solid state multimeter

HICKOK ELECTRICAL INSTRUMENT COMPANY
10514 Dupont Avenue • Cleveland, Ohio 44108 • Phone 216-541-8060

TECHNICAL MANUAL

GENERAL PURPOSE ELECTRONIC MULTIMETER 1604M

THE HICKOK ELECTRICAL INSTRUMENT CO.
10514 Dupont Avenue Cleveland 8, Ohio

30 JANUARY 1968
(Revised August 1969)

BE PREPARED for the EMERGENCY

Know How!

DROWNING

1. REMOVE FROM WATER
2. LOOSEN CLOTHING
3. PLACE PATIENT FACE UPWARDS - CLEAR MOUTH IF NECESSARY
4. APPLY ARTIFICIAL RESPIRATION
5. SEND FOR A DOCTOR
6. KEEP WARM - WITH BLANKETS, ETC.

GASSING

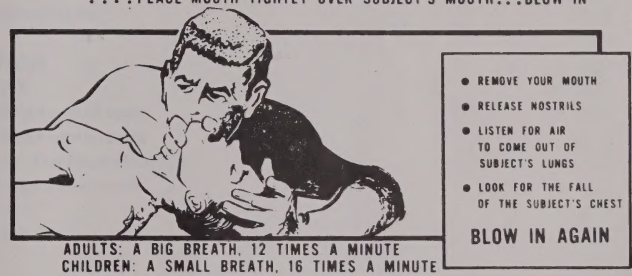
1. REMOVE TO FRESH AIR
2. LOOSEN CLOTHING
3. PLACE PATIENT FACE UPWARDS - CLEAR MOUTH IF NECESSARY
4. APPLY ARTIFICIAL RESPIRATION
5. SEND FOR A DOCTOR
6. KEEP WARM - WITH BLANKETS, ETC.

ELECTRIC SHOCK

1. PROTECT YOURSELF - WITH DRY INSULATING MATERIAL DRY LEATHER, WOOD, RUBBER ETC.
2. BREAK THE CIRCUIT - BY OPENING THE POWER SWITCH OR BY PULLING THE VICTIM FREE OF THE LINE CONDUCTOR
3. DON'T TOUCH THE VICTIM WITH THE BARE HANDS - UNTIL THE CIRCUIT IS BROKEN
4. REMOVE FALSE TEETH, CHEWING GUM, ETC. - FROM THE VICTIM'S MOUTH
5. START ARTIFICIAL RESPIRATION QUICKLY
6. SEND FOR A DOCTOR
7. KEEP PATIENT WARM - WITH BLANKETS, ETC.

MOUTH TO MOUTH BREATHING

. . . . PLACE MOUTH TIGHTLY OVER SUBJECT'S MOUTH . . . BLOW IN



- REMOVE YOUR MOUTH
- RELEASE NOSTRILS
- LISTEN FOR AIR TO COME OUT OF SUBJECT'S LUNGS
- LOOK FOR THE FALL OF THE SUBJECT'S CHEST

BLOW IN AGAIN

ADULTS: A BIG BREATH, 12 TIMES A MINUTE
CHILDREN: A SMALL BREATH, 16 TIMES A MINUTE

AIR PASSAGES MUST BE KEPT OPEN AT ALL TIMES

IF AIR PASSAGES ARE NOT OPEN THERE WILL BE
NO SOUND OF ESCAPING AIR
NO RISE OR FALL OF THE CHEST
RESISTANCE WHEN BLOWING INTO THE SUBJECT'S MOUTH

THEREFORE CHECK NECK AND HEAD POSITION AGAIN
CHECK MOUTH AND THROAT FOR FOREIGN SUBSTANCES.

AIR MAY GO TO STOMACH WHICH WILL DISTEND IT.
TAKE HAND FROM CHIN, PRESSING STOMACH GENTLY, FORCING AIR OUT.

TABLE OF CONTENTS

Part	Title	Page
0	DATA SUMMARY	0-1
	INTRODUCTION	0-1
	Purpose	0-1
	Description	0-2
	EQUIPMENT DATA	0-2
	Equipment Supplied	0-2
	Performance Characteristics	0-2
	Semiconductor Complement	0-3
1	OPERATING INSTRUCTIONS	1-1
	Introduction	1-1
	Functions of Controls and Accessories	1-1
	Test Connections	1-1
	Function Switch	1-1
	Range Switch	1-1
	Front Panel Adjustments	1-2
	Meter	1-3
	Ground Plug	1-3
	Preparation for Use	1-3
	Operating Procedures	1-4
2	THEORY OF OPERATION	2-1
	GENERAL THEORY	2-1
	AC Voltage Measurements	2-1
	DC Voltage Measurements	2-1
	Direct Current Measurements	2-1
	Resistance Measurements	2-1
	DETAILED THEORY	2-6
	TEST CONNECTIONS	2-6
	AC Probe	2-6
	DC Volts Test Prod	2-6
	Ohms, Ma Test Lead	2-8
	Common Test Lead	2-8
	SWITCHING ARRANGEMENT AND VOLTAGE DIVIDER	2-8
	POWER SUPPLIES	2-9
	Photo Cell Supply	2-9
	Secondary Supplies	2-9
	DC AMPLIFIER	2-9
	FEEDBACK AND METER CIRCUIT	2-10
3	UNIT MAINTENANCE INSTRUCTIONS	3-1
	Performance Checks	3-1
	Trouble Shooting	3-2

TABLE OF CONTENTS

Part	Title	Page
4	REPAIR, OVERHAUL AND CALIBRATION	4-1
	General	4-1
	Power Supplies	4-1
	Chopper Drive Circuit	4-1
	Amplifier	4-2
	Feedback Circuit	4-2
	Switches and Front Panel Controls	4-3
	Replacement of Components	4-3
	Calibration Procedures	4-4
	DC Volts	4-5
	DC Amperes	4-7
	AC Volts	4-9
	Chopper Drive Frequency	4-11
	Cleaning Materials	4-12
5	PACKAGING, PRESERVATION AND STORAGE	5-1
	Packaging	5-1
6	PART LIST	6-1
	Introduction	6-1
	Group Assembly Part List	6-1
	Figure and Index Number Columns	6-1
	Part Number Column	6-1
	Vendor Part Numbers	6-1
	Nomenclature Column	6-2
	Vendor Codes	6-2
	Stark Specification Numbers	6-2
	Attaching Parts	6-4
	Items Not Listed	6-4
	Units Per Assembly Column	6-4
7	ILLUSTRATIONS	7-1

LIST OF FIGURES

Figure	Title	Page
0-1	General Purpose Electronic Multimeter FSN 6625-168-0503 (HICKOK MODEL 1604M)	0-1
0-2	List of Equipment Supplied	0-3
0-3	Semiconductor and Tube Complement	0-4
1-1	Front Panel Markings	1-1
1-2	Multimeter Operating Controls	1-2
1-3	Meter Markings	1-3
2-1	AC Voltage Measurements - Functional Diagram	2-2
2-2	DC Voltage Measurements - Functional Diagram	2-3
2-3	Direct Current Measurements - Functional Diagram	2-4
2-4	Resistance Measurements - Functional Diagram	2-5
2-5	Multimeter Model 1604M - Functional Block Diagram	2-7
3-1	Trouble Shooting Chart	3-2
4-1	Power Supply Voltages	4-2
4-2	Waveform Across L3 and L4	4-2
4-3	Amplifier Voltage Check	4-3
4-4	Servicing Etched Circuit Boards	4-4
4-5	Calibration Circuit Board, Location Diagram	4-5
4-6	Test Set-Up for Calibration of DC Volts Circuitry	4-6
4-7	Test Set-Up for Calibration of DC Amperes Circuitry	4-8
4-8	Test Set-Up for Calibration of AC Volts Circuitry	4-10
4-9	Test Set-Up for Calibration of Chopper Drive Circuitry	4-11
6-1	List of Abbreviations	6-1
6-2	List of Manufacturers	6-2
6-3	Electronic Multimeter, 1604M	6-6
6-4	Test Lead Assembly - AC Probe	6-14
6-5	Test Lead Assemblies	6-16
6-6	Input Circuit Assembly, Part No. 152-2-15	6-18
6-7	Chopper Drive Assembly, Part No. 152-2-9	6-20
6-8	Front Panel Assembly	6-22
6-9	FUNCTION Switch Assembly, Part No. 152-2-16	6-26
6-10	RANGE Switch Assembly, Part No. 152-2-7	6-28
6-11	Rear Panel Assembly	6-32
6-12	Amplifier Assembly, Part No. 152-2-8	6-34
6-13	Calibration Board Assembly, Part No. 152-2-10	6-38
6-14	Power Supply Assembly, Part No. 152-2-11	6-40
7-1	Electronic Multimeter, 1604M, Schematic Diagram	7-3,7-4

PART 0
DATA SUMMARY

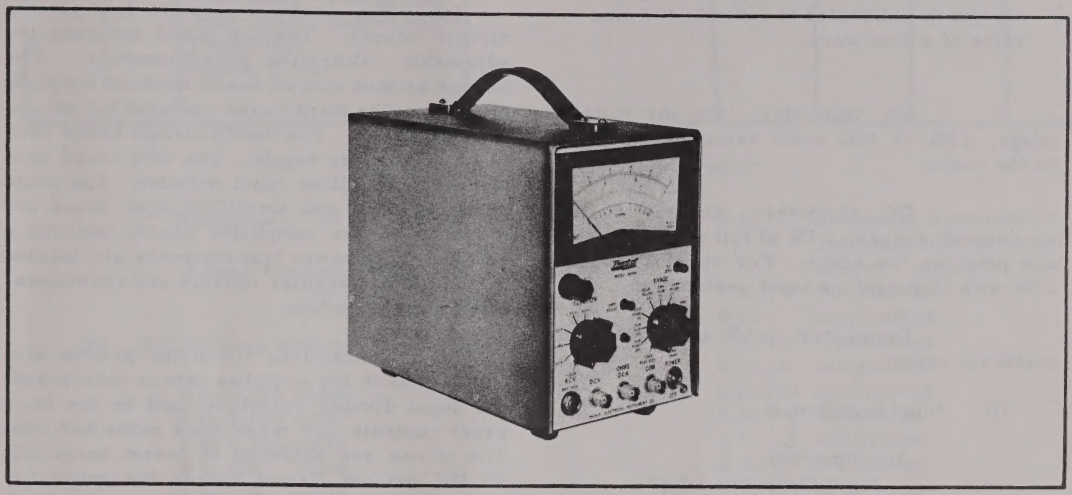


Fig. 0-1 General Purpose Electronic Multimeter, FSN 6625-168-0503 (Hickok Model 1604M)

INTRODUCTION

PURPOSE

0-1 (a) The general purpose Electronic Multimeter, FSN 6625-168-0503 (Hickok Model 1604M), is a portable multimeter, manufactured for Hickok by Stark Electronic Instruments Ltd., Ajax, Ontario. It provides an accurate means of measuring a wide range of ac voltage, dc voltage, current and resistance with extremely low-power absorption from the circuit under test.

(b) When used as a dc voltmeter, the meter is capable of indicating full scale for ranges between ± 15 millivolts and ± 1,500 volts. As a dc ammeter, indications may be obtained for ranges between ± 1.5 μa and ± 150 ma. Also special ranges of ± 1.5, ± 5 and ± 15 nano amps may be monitored using the dc voltmeter probe. Resistance measurements can be made under 1 ohm and over 500 megohms. By means of a special rectifying probe, ac voltage between 0.5 and 300 volts (rms) can be measured, over a wide range of frequencies from 20 Hz to 700 mHz.

(c) The electronic voltmeter is a self-contained portable multimeter, ruggedly designed with solid-state circuitry for general field servicing applications. It is particularly suited to mobile ground facilities.

(d) Frequency:

Range for ac measurements 20 Hz to 700 mHz.

Response: Flat within ± 1 db from 20 Hz to 700 mHz.

(e) Accuracy of Calibration:

AC voltmeter: On any voltage range, ± 3% of full scale value at any point on the scale for sinusoidal ac voltages from 100

Hz to 100 mHz, and within one db from 20 Hz to 700 mHz for sinusoidal voltages.

NOTE

The instrument is positive peak responding and is calibrated to indicate the rms value of a sine wave.

DC voltmeter: On any voltage range, ± 2% of full scale value at any point on the scale.

DC ammeter: On any of the 11 current ranges, ± 3% of full scale value at any point on the scale. For special ranges: ± 5% with 10 megohms input resistance.

Ohmmeter: ± 5% of reading at midscale value.

(f) Input Impedance:

AC voltmeter:
Input Capacity: 1.5 pf

Input Resistance:
For frequencies up to 10 KHz: 10 megohms

For frequencies from 10 KHz to 10 mHz: 1 megohm

DC voltmeter: Input Resistance:

On 500 mv range and above: 100 megohms ± 1%

On 15, 50 and 150 mv ranges: 10 megohms ± 1%

DC ammeter: Input Resistance:

9K ohms on 1.5 μa scale, decreasing to 0.3 ohms on the 150 ma scale.

DESCRIPTION

0-2 (a) The multimeter consists of a front panel, a deep rectangular chassis and a rear panel, and is enclosed in a sheet metal case.

(b) The front panel contains a moving coil taut-band milliammeter, suitably calibrated for the various functions to be measured. All switches and adjustments required during operation of the multimeter, and connectors for the test leads, are located on the front panel.

(c) The chassis supports five printed circuit boards. The top board incorporates adjustable calibration potentiometers. The second printed circuit board contains the photo chopper. The third board contains the amplifier circuitry. The fourth circuit board consists of a power supply. The fifth board contains the amplifier input network. The photo chopper board and amplifier input board are mounted on the amplifier board, beneath a shield. Both power transformers are located inside the rectangular chassis and are accessible from the bottom.

(d) Connections from the printed circuit boards to the switches (which incorporate the input divider resistors) and to the front panel controls are made via a cable harness. The wires are soldered to turret terminals on the printed circuit boards for reliability but can be removed easily for maintenance or trouble shooting purposes.

(e) On the rear panel is the line fuse, a voltage selector and a grounding plug. This plug enables the instrument to be used with the common test lead grounded to the chassis and ac line ground, or with the common test lead floating.

EQUIPMENT DATA

EQUIPMENT SUPPLIED

0-3 Details of equipment supplied, including test leads, prods and probes are given in Fig. 0-2.

PERFORMANCE CHARACTERISTICS

0-4 The performance characteristics of the Multimeter are as follows:

(a) Power requirements:

Input Voltage: 115/230 volts ± 10%, single phase

Qty. Per Equipment	Name of Item and AN Designation	Federal Stock Number	Overall Dimension (in.)			Net Weight lb.
			Height	Width	Depth	
1	General Purpose Electronic Multimeter	6625-168-0503	7-1/2	5-1/2	9-1/2	10
1	Test Prod (dc)					
1	Test Lead - (ohms-ma)					
1	Test Lead - (common)					
1	Probe (ac)					
1	Power Cord					

Fig. 0-2 List of Equipment Supplied

Frequency: 50 to 1,100 Hz

Power Consumption: 14 watts (including ac probe)

(b) DC Voltage Ranges:

0 to 0.015 volts
0 to 0.050 volts
0 to 0.150 volts
0 to 0.5 volts
0 to 1.5 volts
0 to 5 volts
0 to 15 volts
0 to 50 volts
0 to 150 volts
0 to 500 volts
0 to 1500 volts

(c) AC Voltage Ranges:

0 to 0.5 volts
0 to 1.5 volts
0 to 5 volts
0 to 15 volts
0 to 50 volts
0 to 150 volts
0 to 300 volts

(d) DC Amperage Ranges + or -

0 to 1.5 nanoamps measured on 15 millivolt dc range with dcv probe
0 to 5 nanoamps measured on 50 millivolt dc range with dcv probe
0 to 15 nanoamps measured on 150 millivolt dc range with dcv probe
0 to 1.5 microamps
0 to 5 microamps
0 to 15 microamps
0 to 50 microamps
0 to 150 microamps
0 to 0.5 milliamps
0 to 1.5 milliamps
0 to 5 milliamps
0 to 15 milliamps
0 to 50 milliamps
0 to 150 milliamps

(e) Resistance:

Rx10 0 to 500 ohms, 10 ohms centre scale
Rx100 0 to 5 K ohms, 100 ohms centre scale
Rx1 K 0 to 50 K ohms, 1 K ohms, centre scale
Rx10 K 0 to 500 K ohms, 10 K ohms, centre scale
Rx100 K 0 to 5 Megohms, 100K ohms, centre scale
Rx1 Meg 0 to 50 Megohms, 1 Megohm, centre scale
Rx10 Meg 0 to 500 Megohms, 10 Megohms, centre scale

SEMICONDUCTOR COMPLEMENT

0-5 The multimeter is built up entirely of solid-state circuitry with the exception of the special ac probe. Fig. 0-3 contains the semiconductor and tube complement.

Fig. 0-3

Reference Designation	Type	Description	Quantity
Z1	VR33	Zener diode	1
Z2	VR18	Zener diode	1
Z3	1N1602	Zener diode	1
Z4	BZY58	Zener diode	1
Z5	VR14	Zener diode	1
D1, D2	1N4367	Diode	2
D3, D4, D5, D6, D7, D8, D11	1N4364	Diode	7
D9, D10	1N457	Diode	2
PH1, 2	NSL367C (Part No. 138-2-56)	Photocells (matched pair for input)	2
PH3, 4	NSL367C (Part No. 138-2-57)	Photocells (matched pair for output)	2
Q1	2N2386 or 2N3820	Field effect transistor	1
Q2	2N3708	Transistor	1
Q3, Q4, Q5	2N1377	Transistor	3
Q6, Q7	2N3711	Transistor	2
L1, L2	ZA1003/4	Neon regulator	2
L3, L4	NE2H (Part No. 125-9-33)	Neon lamps (matched pair)	2
V1	EA53	UHF diode (ac probe)	1

Fig. 0-3 Semiconductor and Tube Complement

PART 1
OPERATING INSTRUCTIONS

INTRODUCTION

1-1 This part provides complete instructions for the operation of the general purpose Electronic Multimeter. These instructions include information pertaining to general test set-ups as well as switch functions and descriptions of calibration adjustments permissible during operation.

FUNCTIONS OF CONTROLS AND ACCESSORIES

1-2 All switches, (except the voltage selector) adjustments, test lead connections, and the meter, pertinent to the operation of the multimeter, are located on the front panel. See Fig. 1-1.

CAUTION

Functions and ranges which may be used for ac measurements are marked in red on the front panel. On the meter, the two red scales are for ac measurement on the 0.5 and 1.5 volt ranges. Above 1.5 vac, measurements are read on the black scales.

TEST CONNECTIONS

1-3 AC PROBE

(a) The ac probe incorporates a special diode with cathode heater for making measurements up to ultra-high frequencies. The probe is positive peak responding and produces a negative dc voltage which is applied to the multimeter circuitry. The probe lead is attached to the front panel through a telephone type jack.

1-4 DC TEST LEADS

(a) For measuring dc volts, a test prod is supplied which incorporates a one megohm resistor in an insulated handle. The test lead for measuring either dc current (ma) or resistance is terminated in an alligator clip with an insulated red handle. The common test lead is also terminated in an alligator clip and an insulated black handle. All dc leads are connected to the front panel through BNC type receptacles.

FUNCTION SWITCH

1-5 The FUNCTION switch is a six-position, three-wafer ceramic switch which selects the appropriate circuit for the function to be measured and also determines the correct polarity of the meter. Fig. 1-2 lists the switch positions and their functions.

RANGE SWITCH

1-6 (a) The RANGE switch is an eleven-position, three-wafer ceramic switch which selects the appropriate resistive network to provide the desired full scale value on the meter.

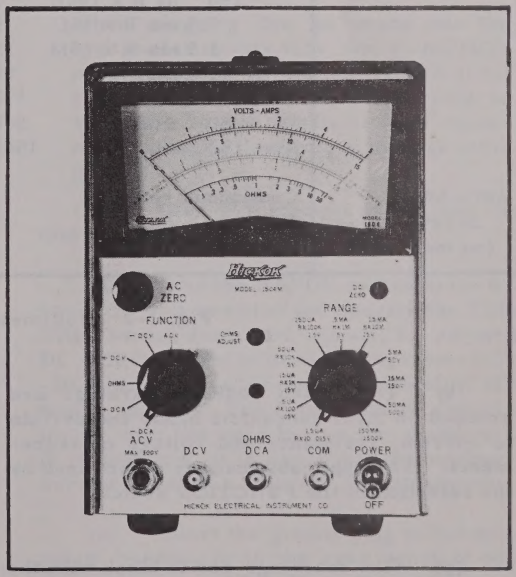


Fig. 1-1 Front Panel Markings

Nomenclature	Positions	Functions
Voltage Selector (SW2)	115-230	Enables selection of the appropriate input supply to the primary of the power transformers T1 and T2
Power Switch (SW1)	ON (up) - OFF (down)	When the unit is connected to the power source the power switch controls the application of the supply to the primary of the power transformers T1 and T2
Power On Lamp (PL1)		Lights up when voltage is applied across transformers
Function Switch (F)	(ccw) -DC AMPS +DC AMPS OHMS +DC VOLTS -DC VOLTS (cw) AC VOLTS (marked in red)	The FUNCTION switch determines the circuit whereby the desired measurement can be made. The selector also establishes the correct polarity for the meter
Range Switch (R)	(ccw) 1.5 μa R x 10 — 0.015 volts 5 μa R x 100 — 0.05 15 μa R x 1K — 0.15 50 μa R x 10K — 0.5 150 μa R x 100K — 1.5 0.5 ma R x 1M — 5) marked 1.5 ma R x 10M — 15) 5 ma — 50) in 15 ma — 150) 50 ma — 500) (cw) 150 ma — 1500) red	The RANGE switch contains three calibration arcs and determines the readings for full scale deflection on the meter
Zero Adjust Screw (on meter)	Continuous rotation	Provides mechanical adjustment of pointer for zero indication

Fig. 1-2 Multimeter Operating Controls

(b) The switch position markings are grouped in three concentric bands and pertain to current, resistance and voltage measurements. The applicable band is determined by the selection of the FUNCTION switch.

(c) The markings are in black with the exception of the voltage range from 0.5 to 500. These are in red to indicate that these ranges are used for ac as well as dc measurements. Fig. 1-2 lists the switch positions and their functions.

FRONT PANEL ADJUSTMENTS

1-7 The front panel contains three adjustments: AC ZERO, OHMS ADJUST and DC ZERO. The AC ZERO potentiometer (R37) is

Arc	Calibration	Type of Scale	Colour	Function
1 (upper)	0 to 5)	linear	black	DC volts and DC current AC volts above 5 volts
2	0 to 15)			
3	0 to 0.5 vac)	non-linear	red	AC volts only
4	0 to 1.5 vac)			
5	0 to ∞ with 1 ohm in centre	non-linear	black	ohms

Fig. 1-3 Meter Markings

adjusted by means of a control knob, whereas the OHMS ADJUST and DC ZERO potentiometer (R34 and R61) may be adjusted with a screwdriver or by hand as desired.

METER

1-8 The meter, M1, is a moving-coil, taut-band milliammeter, the polarity of which is controlled by the FUNCTION switch. The meter dial contains five arcs compatible with the positions of the FUNCTION switch. Details of the calibrations are given in Fig. 1-3.

GROUND PLUG

1-9 On the rear of the unit is a ground plug and three coloured jacks. When the ground plug is placed between the black and white jacks, the chassis ground and circuit common are interconnected. When the ground plug is between the white and red jacks the chassis ground is floating.

PREPARATION FOR USE

1-10 The multimeter requires a power source of 115/230 vac ± 10%, 50 to 1,100 Hz to operate. Before the unit can be used to measure ac voltages, a warm-up period of 20 minutes is necessary. During this period the unit can be used for making dc and resistance measurements, commencing shortly after the equipment is energized. Carry out the following procedure:

(a) Select the appropriate voltage position on the rear panel. (i.e. 115/230 vac). Connect the power cord to the correct power supply.

(b) Turn the FUNCTION switch counter-clockwise to any position other than AC VOLTS. Connect the test leads to their appropriate receptacle on the front panel.

CAUTION

When plugging the ac probe into the multimeter ensure that the FUNCTION switch is NOT in the AC VOLTS (CW) position, as the diode heater would be subjected to the application of maximum voltage, resulting in damage to the probe.

(c) Turn on the power switch and check that the power on lamp is lit.

(d) Turn the RANGE switch to the 0.015 or 0.050 volt position and operate the FUNCTION switch from +DCV to -DCV. Adjust the DC ZERO control until switching from +DCV to -DCV does not alter the final position of the meter pointer. The final position should coincide with the zero line on the meter scale. If it does not, it is likely that the mechanical zero of the meter requires re-adjustment.

(e) Insert the ground plug in the appropriate receptacle in the rear panel to obtain the desired normal or floating ground.

OPERATING PROCEDURES

1-11(a) To measure a negative or positive dc voltage operate the FUNCTION switch to the -DCV (negative) or +DCV (positive) position respectively, and the RANGE switch fully clockwise. Connect the common test clip to the ground point of the circuit under test and place the DC VOLT test prod at the point to be measured. Rotate the RANGE switch in a counter-clockwise direction until the meter pointer moves to a readable position on the dial scale. The magnitude of the voltage is then determined by the value of the reading modified by the value inscribed at the position of the RANGE switch.

(b) To measure negative or positive direct current, repeat the procedure in step (a) utilizing the OHM/MA test clip in place of the dc volt test prod, and using the +DCA or -DCA position on the FUNCTION switch.

(c) Resistance measurements are made utilizing the same procedure as in step (b), using the OHMS position on the FUNCTION switch. Ensure that with the test leads disconnected, the meter pointer reads full-scale deflection. If it does not do so, adjust the OHMS ADJUST control until full-scale deflection is achieved. Note that for proper indication, the DC ZERO control must have been adjusted as outlined in para 1-10 (d).

(d) To measure ac voltages, ensure that the unit has been energized for 20 minutes and that the DC ZERO control has been properly set as outlined in 1-10 (d). Operate the FUNCTION switch to AC VOLTS, the RANGE switch to the 0.5 volt range and connect the ac probe tip to the ground lead. Adjust the AC ZERO control until the meter pointer indicates zero, then disconnect the ground lead. Operate the RANGE switch to the 500 volt range; connect the probe tip to the point to be measured and connect the ac common to the ground point in the circuit under test. Rotate the RANGE switch in the counterclockwise position until the meter pointer moves to a readable position on the dial scale. Modify the indication by the value of the position of the RANGE switch to obtain the magnitude of the voltage.

NOTE

For frequencies up to 10 mHz, the voltage to be measured may be connected between the AC VOLT probe tip and the COM test lead. Above these frequencies, the ground lead on the probe housing should be used. For frequencies above 200 mHz it is advisable to remove the probe lead and couple to the circuit under test with a ceramic capacitor with extremely short leads or use an appropriate 'T' connector to obtain better accuracy. Also above 100 mHz the maximum voltage which may be applied to the probe input is derated from 300 v rms at 100 mHz to 100 v rms at 700 mHz.

CAUTION

When the FUNCTION switch is operated to the ACV position the common test lead and ACV ground lead are automatically connected to chassis ground and hence to the power system ground.

PART 2
THEORY OF OPERATION

GENERAL THEORY

2-1 This part presents complete operational theory of the General Purpose Electronic Multimeter, Model 1604. A general introductory description of the system is given, with reference to functional diagrams, to present the theory in terms of operating functions. This is followed by a detailed analysis of the circuit and its component parts.

2-2 The multimeter is a low-voltage, high-impedance multimeter, which draws extremely low power from the circuit under test. The input to the unit is a high-impedance voltage divider on the unit and contains a dc amplifier which provides the energy to deflect the meter.

AC VOLTAGE MEASUREMENTS

2-3 Refer to Fig. 2-1. When the FUNCTION switch is set to the AC VOLTS position, the heater of diode V1 is connected directly to the +6 volt supply, since series resistor R11 is short circuited by wafer F3B. Simultaneously, the common is connected to the chassis ground.

2-4 The ac voltage to be measured is applied across diode V1 and common. The resultant negative dc is applied between point Q on the voltage divider and ground. Because of the selection of R1F and F2B, resistors R12 and R13 are connected in series with the divider, affecting a high input impedance.

2-5 A positive dc voltage derived from the 6.8 volt supply is applied to tap P on the voltage divider to overcome random noise present in the input. The potential applied is controlled by the AC ZERO adjust potentiometer, R37, which is isolated with a high resistance, R38, from the amplifier input.

2-6 Operation of the RANGE switch connects the amplifier input to the desired tap on the voltage divider, thus modifying the amount of input voltage necessary to cause the meter to deflect to full scale.

DC VOLTAGE MEASUREMENTS

2-7 Refer to Fig. 2-2. The negative or positive voltage to be measured is applied across the voltage divider from point Q to common. For certain selections of the RANGE switch, resistors R12 and R13 are added to the divider in series. The appropriate meter scale is determined by the RANGE switch, which switches the amplifier input to the desired tapping point on the voltage divider. The resulting signal, either negative or positive is fed to the amplifier and the meter deflects to indicate the voltage. Wafer F1F on the FUNCTION switch interchanges the meter connections so that the meter deflects to the right for both positive and negative measurements.

DIRECT CURRENT MEASUREMENTS

2-8 Refer to Fig. 2-3. When the FUNCTION switch is in either the -DC AMPS or +DC AMPS position, the current to be measured is fed through F1B of the FUNCTION switch to R4B of the RANGE switch. Depending upon the RANGE switch selection which determines the meter scale, the current flows through a portion of the voltage divider to ground. This produces a voltage between O and common on the divider which causes the meter to deflect. When the negative position (-DC AMPS) is selected on the FUNCTION switch, the polarity of the meter is reversed.

RESISTANCE MEASUREMENTS

2-9 The functional diagram for resistance measurements is shown in Fig. 2-4. With the FUNCTION switch in the OHMS position, a

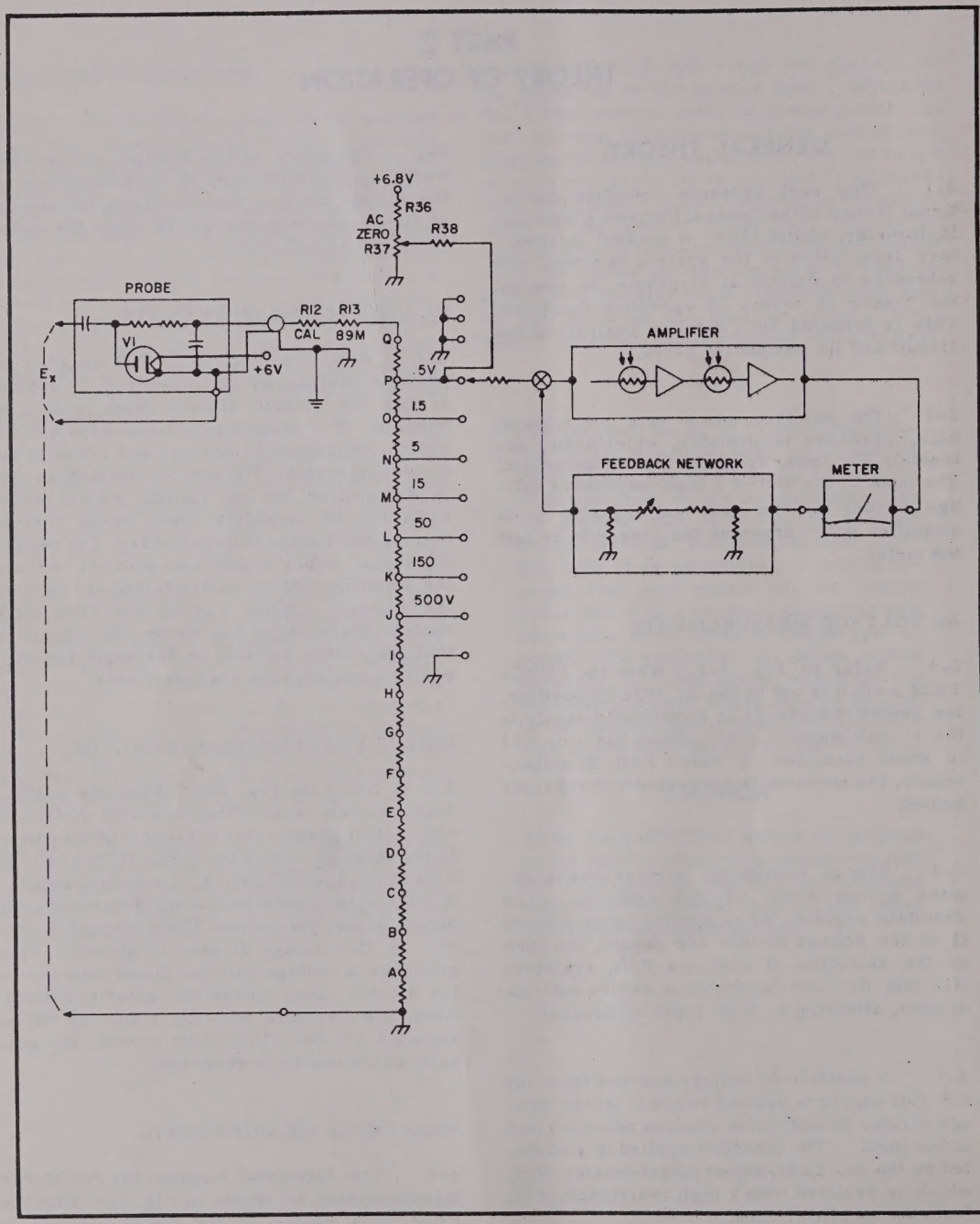


Fig. 2-1 AC Voltage Measurements - Functional Diagram

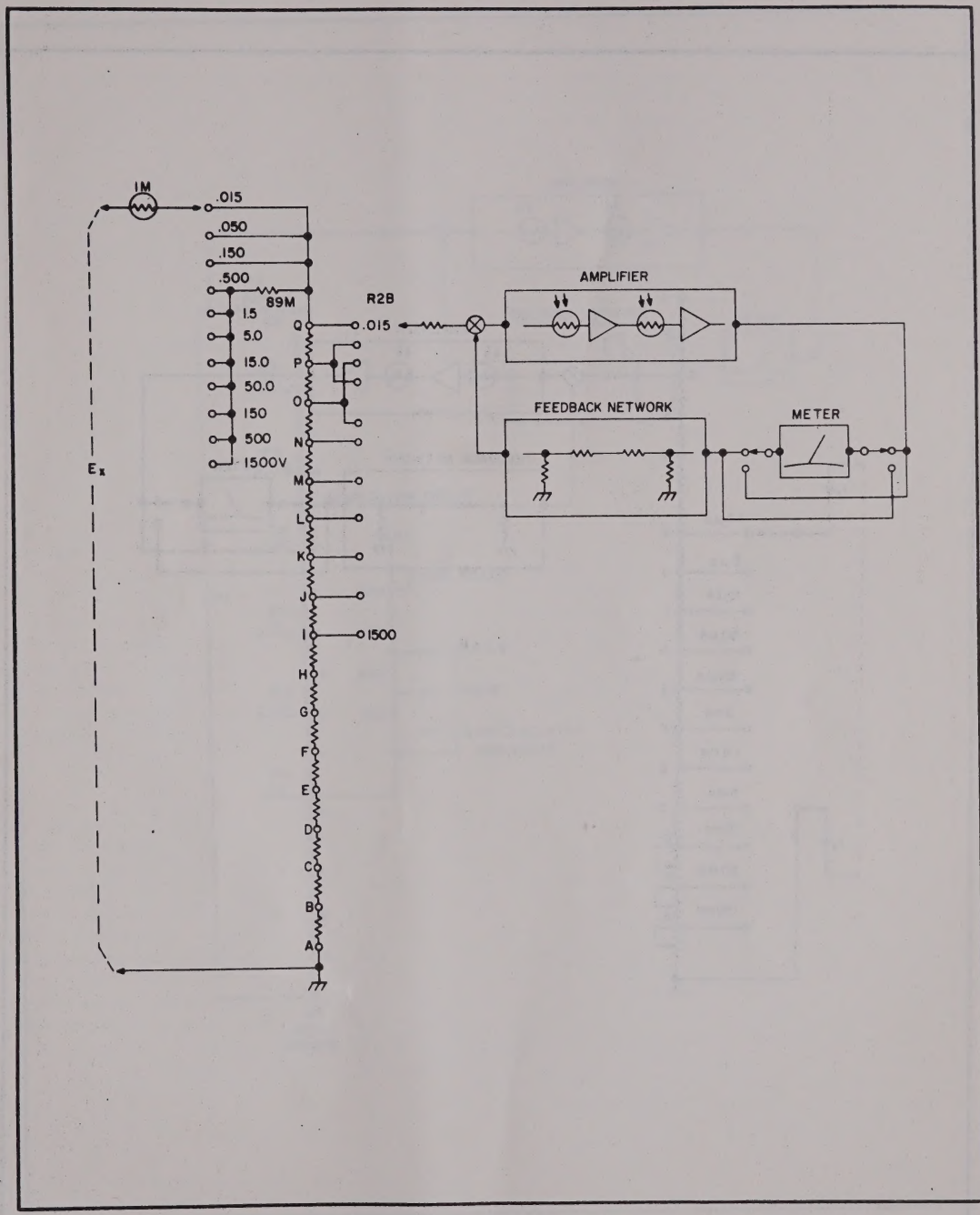


Fig. 2-2 DC Voltage Measurements - Functional Diagram

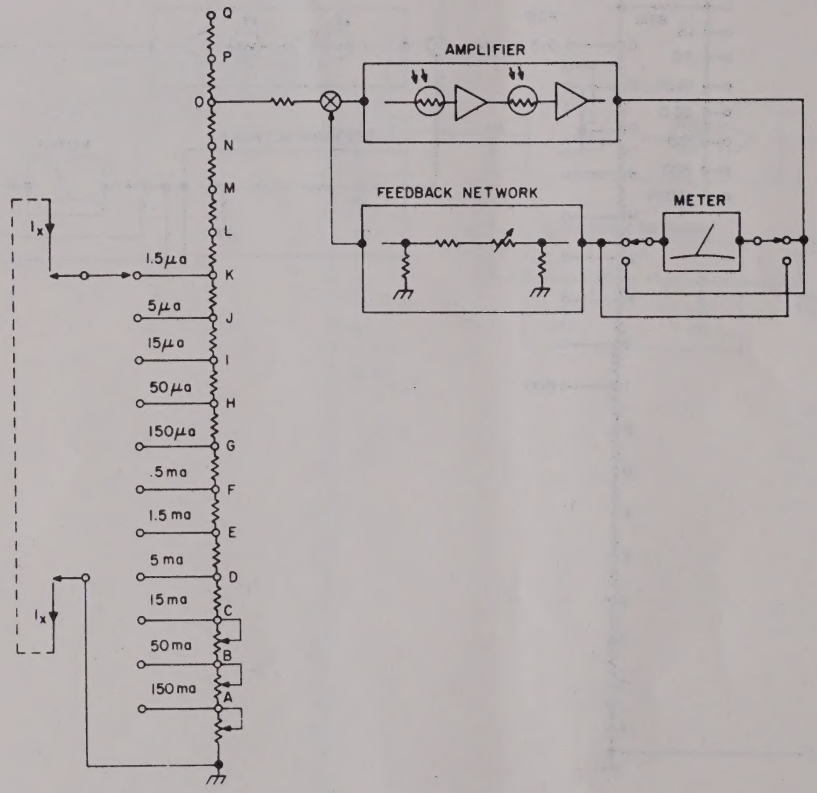


Fig. 2-3 Direct Current Measurements - Functional Diagram

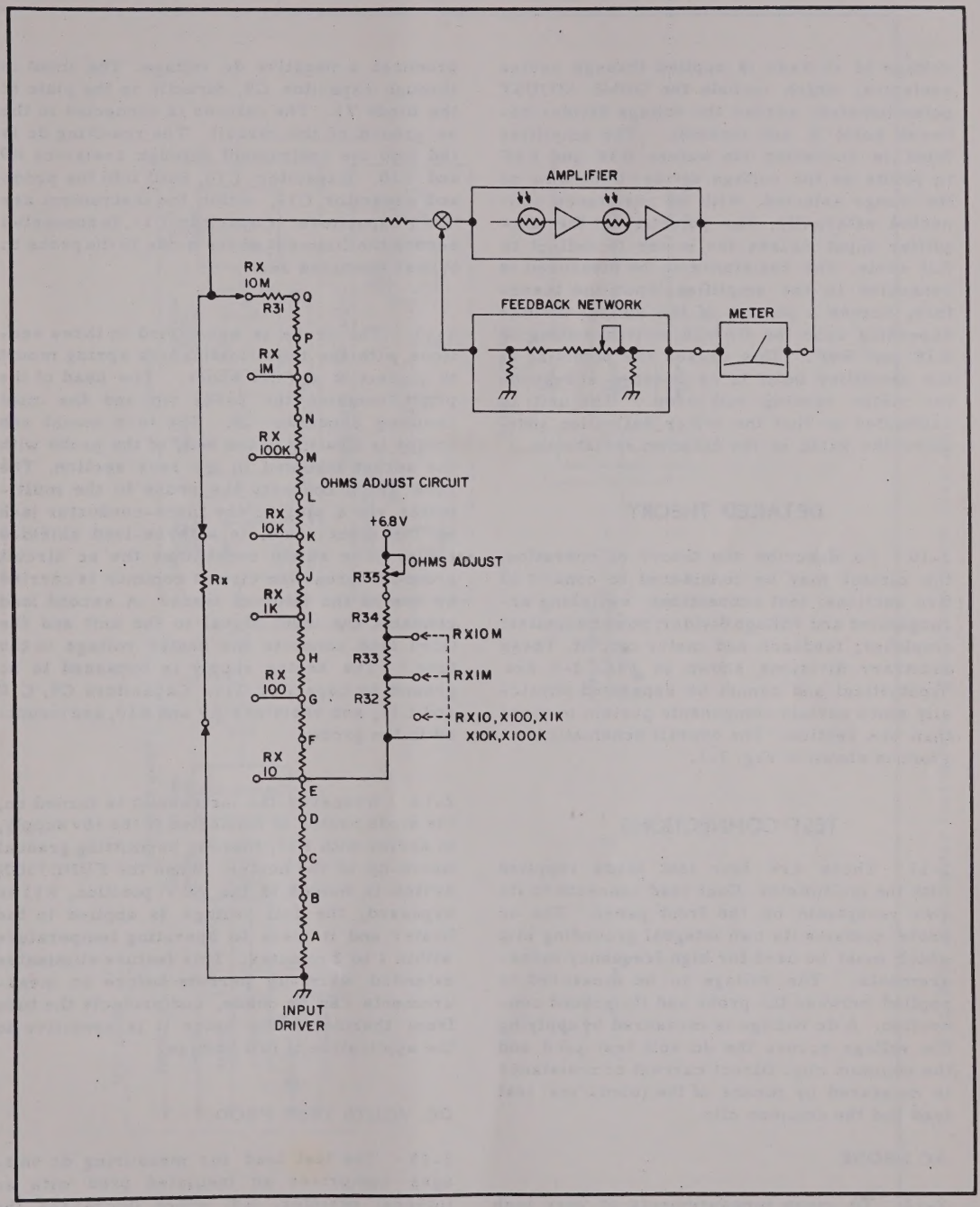


Fig. 2-4 Resistance Measurements - Functional Diagram

voltage of +6.8 vdc is applied through series resistors, which include the OHMS ADJUST potentiometer, across the voltage divider between point E and common. The amplifier input is connected via wafers R3F and R4F to points on the voltage divider depending on the range selected. With no resistance connected externally, the potential at the amplifier input causes the meter to deflect to full scale. The resistance to be measured is connected to the amplifier input and therefore, across a portion of the voltage divider depending upon the RANGE switch setting of R3F and R4F. This causes the potential at the amplifier input to be lowered and hence the meter reading will drop. The unit is calibrated so that the meter deflection indicates the value of the unknown resistance.

DETAILED THEORY

2-10 To describe the theory of operation, the circuit may be considered to consist of five sections: test connections; switching arrangement and voltage divider; power supplies; amplifier; feedback and meter circuit. These arbitrary divisions shown in Fig. 2-5 are hypothetical and cannot be separated physically since certain components pertain to more than one section. The overall schematic diagram is shown in Fig. 7-1.

TEST CONNECTIONS

2-11 There are four test leads supplied with the multimeter. Each lead connects to its own receptacle on the front panel. The ac probe contains its own integral grounding clip which must be used for high frequency measurements. The voltage to be measured is applied between the probe and its ground connection. A dc voltage is measured by applying the voltage across the dc volt test prod and the common clip. Direct current or resistance is measured by means of the (ohms/ma) test lead and the common clip.

AC PROBE

2-12 To make measurements at very high frequencies, the ac probe incorporates a UHF diode tube with a special cathode heater. The probe itself is positive-peak responding and produces a negative dc voltage. The input is through capacitor C9, directly to the plate of the diode V1. The cathode is connected to the ac ground of the circuit. The resulting dc is fed into the instrument through resistors R9 and R10. Capacitor C10, built into the probe and capacitor C12, within the instrument are filter capacitors. Capacitor C11, is connected across the filament of the diode in the probe to bypass unwanted ac.

2-13 The probe is assembled in three sections with the tube floating in a spring mount to protect it against shock. The head of the probe contains the probe tip and the input coupling capacitor C9. The tube mount and holder is floating in the body of the probe with the socket mounted in the rear section. The cord which connects the probe to the multimeter, via a plug to the three-conductor jack on the front panel, is a three-lead shielded cable. The shield constitutes the ac circuit ground whereas the circuit common is carried by one of the internal leads. A second lead connects the input signal to the unit and the third lead connects the heater voltage to the tube. The heater supply is bypassed to ac ground by capacitor C11. Capacitors C9, C10 and C11, and resistors R9 and R10, are mounted in the probe.

2-14 Whenever the instrument is turned on, the diode heater is connected to the +6v supply, in series with R11, thereby permitting gradual warm-up of the heater. When the FUNCTION switch is moved to the ACV position, R11 is bypassed, the full voltage is applied to the heater and it rises to operating temperature within 1 to 2 minutes. This feature eliminates extended warm-up periods before ac measurements can be made, and protects the tube from thermal shock since it is sensitive to the application of full voltage.

DC VOLTS TEST PROD

2-15 The test lead for measuring dc voltages comprises an insulated prod with an integral resistor, R8, which decreases the effect of capacitance through the cable. The shielded lead is connected to the instrument through a BNC receptacle.

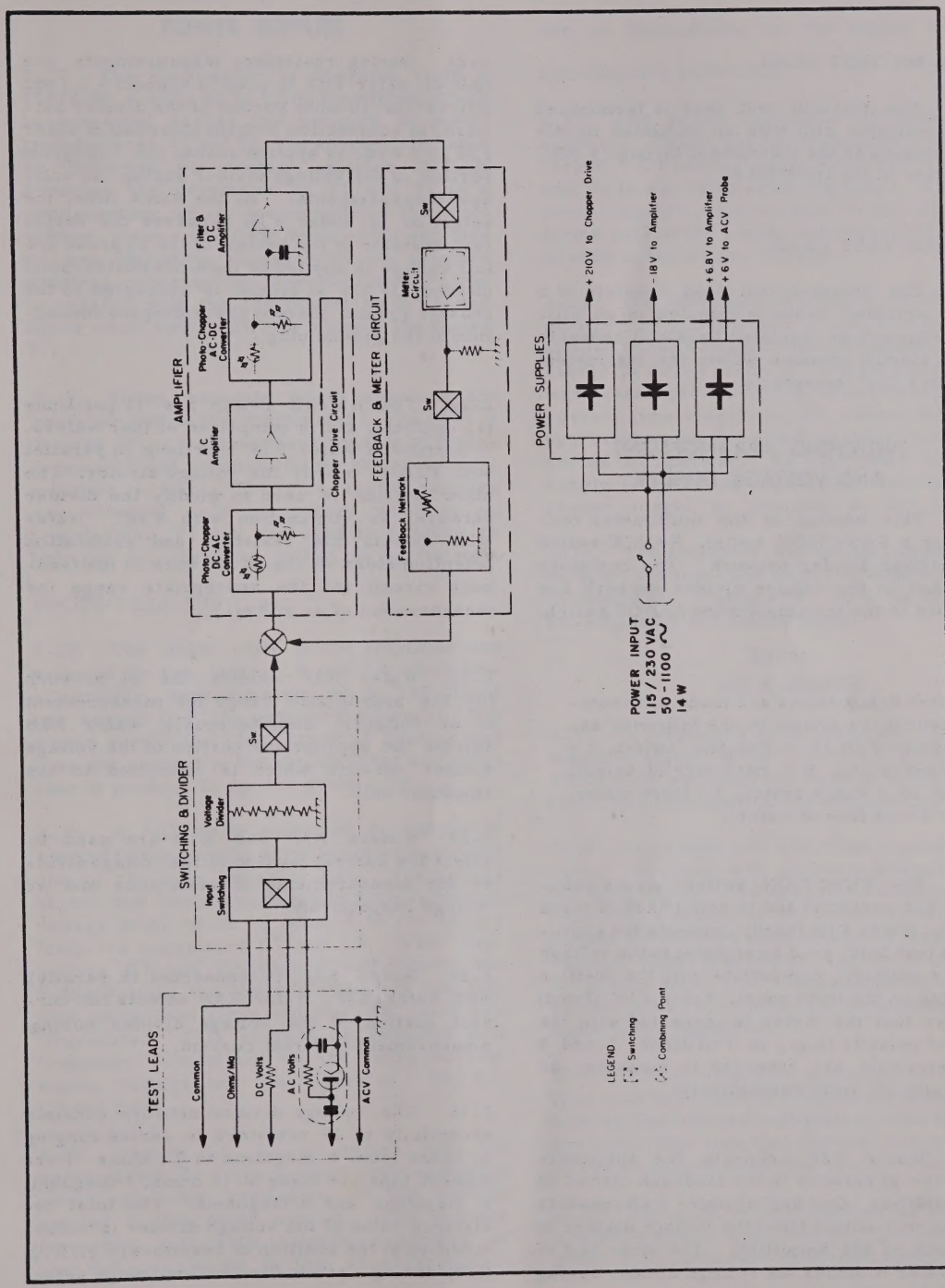


Fig. 2-5 Multimeter Model 1604 - Functional Block Diagram

OHMS, MA TEST LEAD

2-16 The shielded test lead is terminated in an alligator clip with an insulated handle and connects to the instrument through a BNC connector in the front panel.

COMMON TEST LEAD

2-17 The common test lead consists of a single shielded cable terminated in an alligator clip with an insulated handle. It connects to the circuit common within the instrument through a BNC receptacle.

SWITCHING ARRANGEMENT AND VOLTAGE DIVIDER

2-18 This section of the multimeter consists of a FUNCTION switch, RANGE switch and voltage divider network. The resistors contained in the voltage divider network are strapped to the terminals of the RANGE switch.

NOTE

Switch designations are made up in combinations as shown in the following examples: F2B (F = Function switch, 2 = second wafer, B = Back face of wafer); R3F (R = Range switch, 3 = third wafer, F = Front face of wafer).

2-19 The FUNCTION switch has six positions (12 contacts) and is comprised of three wafers. Wafer F1B (back) connects the appropriate test lead, prod or ac probe to the voltage divider network, compatible with the position marking on the front panel. Wafer F1F (front) ensures that the meter is connected with the correct polarity (e.g., in Positions 1 and 5 the terminals are reversed to measure -dc amps and -dc volts respectively).

2-20 Wafer F2F connects the applicable resistive pi network in the feedback circuit of the amplifier. One half of wafer F2B connects the correct output from the voltage divider to the input of the amplifier. The other half of this wafer modifies the voltage divider during ac and dc voltage measurements.

2-21 During resistance measurements one half of wafer F3F is used to connect +6.8 vdc across the 10-ohm portion of the divider network. In conjunction with the other half of wafer F3F, +6.8 vdc is applied across the 3-megohm portion of the voltage divider during ac voltage measurements. At the same time, the selection of wafer F3B bypasses the series load resistor in the heater of the ac probe and full voltage is applied to the diode heater. Simultaneously the ac ground is connected to the chassis ground, thereby overriding the connection of the ground plug.

2-22 The RANGE switch has 11 positions (11 contacts) and is comprised of four wafers. A portion of wafer R1F functions in parallel with F2B to modify the voltage divider. The other portion is used to modify the divider network, in conjunction with F3F. Wafer R1B selects the resistors and calibration potentiometers of the pi network in the feedback circuit for the appropriate range for measurement of ac voltage.

2-23 Wafer R2F selects the pi network for the appropriate range for measurement of dc voltage. Simultaneously, wafer R2B selects the appropriate portion of the voltage divider network which is connected to the amplifier unit.

2-24 Wafers R3F and R3B are used to select the correct portion of the voltage divider for measurements of resistance and ac voltage respectively.

2-25 Wafer R4F is connected in parallel with wafer R3F. Wafer R4B selects the correct portion of the voltage divider during measurement of direct current.

2-26 The voltage divider network consists essentially of 17 resistors in series ranging in value from 6 megohms to 0.1 ohms. Permanent taps are made at 10 ohms, 1 megohm, 3 megohms and 9 megohms. The total resistance value of the voltage divider is further modified by the addition of resistors (e.g., R12, R13) during certain function and range selections.

POWER SUPPLIES

2-27 The multimeter is operated from a 115/230v ± 10%, 50 to 1,100 Hz supply, which is connected across the primary of power transformers T1 and T2. The appropriate input is connected via voltage selector SW2. It arranges the primaries of T1 and T2 in a configuration which accommodates the input voltage. Power ON-OFF switch SW1 and fuse F1 are placed in series with the primary windings, whereas the power-on lamp PL1 is in parallel with the 18v secondary of T1, and lights when switch SW1 is closed. See figure 7-1.

2-28 Three separate power supplies are provided within the multimeter. The first is derived from the secondary winding of transformer T2 and produces dc for the photo cells (chopper exciters). The remaining two supplies are obtained from secondary windings on transformer T1 and are used to produce dc voltages for operation within the multimeter.

PHOTO CELL SUPPLY

2-29 The photo cells in the amplifier are actuated by two lamps L3 and L4 which fire alternately, approximately 80 to 100 times per second (i.e. the chopper frequency). The power supply for this circuit is floating and does not connect to the circuit in any way other than to produce dc for the photo cells.

2-30 A full wave regulated dc voltage is applied to the chopper drive board which causes one of the neon lamps to fire. The voltage across this lamp then drops to the maintaining voltage level which is coupled to the second lamp via capacitors C7 and C8. When capacitors C7 and C8 charge sufficiently, the firing voltage for the other lamp is reached; this lamp then fires and the first lamp extinguishes. This process is repeated at a frequency determined by the magnitude of supply voltage and the values of R6, R7, C7 and C8.

2-31 Lamps L1, L2, in series with the zener diode Z1 form a shunt-type regulator which provides regulation of the voltage applied to the drive circuit. The chopper frequency will shift slightly depending on the voltage charge in this shunt regulator due to fluctuations in the supply voltage.

SECONDARY SUPPLIES

2-32 One of the secondary windings of T1 produces -18 vdc for the transistor-amplifier circuit. C3 and R2 comprise a filter network and Z2 is a parallel zener regulator. A second zener regulator Z4, located in the amplifier forms part of the supply and reduces the effect of shift in the ac line voltage.

2-33 The remaining winding of T1 produces positive dc voltages of 6.8 and 6 volts to be applied to the voltage divider amplifier, and the heater in the ac probe. D7 and D8 provide full wave rectification. C4, C5, R3 and R4 and a high current zener regulator, Z3, reduce the ripple to a level where the effect on the ac probe becomes insignificant. At this point the 6.8v supply is taken off. Additional filtering of the heater supply is provided by R5 and C6.

2-34 The amplifier may be considered to be dc since the input and output is direct current. In intermediate stages the dc is converted to ac, amplified and demodulated.

DC AMPLIFIER

2-35 Irrespective of the measurement being made, a signal is fed through F2B of the FUNCTION switch to the input of the dc amplifier. The true input of the amplifier is R40.

2-36 Preceding R40 are three separate circuits. Resistor R39 provides attenuation of the input signal. C14 is part of a feedback network which speeds up the action of the circuit. Diodes D9 and D10 conduct when a large overvoltage, either positive or negative, is developed across them (i.e., voltages appreciably in excess of 100 millivolts) and hence protect the input to the amplifier.

2-37 The dc amplifier is a highly-stable, dc type with fixed gain. Its impedance is also very high so that it draws negligible current from the dc input. The resultant feature is that minute power is drawn from the circuit under test.

2-38 The gain is held constant by means of a photo-chopper type circuit. The particular photo cells used have sufficient speed of res-

ponse so that they operate in conjunction with the lamps L3 and L4. The advantage of this type of circuit is that switching takes place electronically and the drive circuit is isolated from the amplifier.

2-39 The input resistor R40 provides further attenuation of the input signal, and the input voltage is developed across C13. The photo chopper circuit is switched on and off sequentially by the action of the photo cells PH1 and PH2 and the voltage developed across C13 is changed into square-wave ac at C15. The ac signal is fed into the gate of Q1, a field-effect transistor of high impedance. This impedance is increased by more than one hundredfold, by utilizing negative feedback. The ac amplification circuit is made up of four transistors. The first is of silicon composition. This type functions ideally at high temperatures and hence maintains the high input impedance at these temperatures. The remaining three are germanium since they operate more satisfactorily at low temperatures. Thermistor TH1 is used in the collector of Q3 to offset any changes in bias due to temperature changes.

2-40 The output of the ac amplifier is fed into a second pair of photo cells, PH3 and PH4, whose operation is synchronized with that of PH1 and PH2 so that the ac is demodulated. The dc is filtered by C25, C26 and R62 and is fed into Q6 and Q7. Q6 and Q7 are connected in a "Darlington" configuration.

2-41 The common junction of the emitter Q7, resistors R66 and R67, is the balance point of the circuit. The magnitude of the feedback voltage is used to deflect the meter pointer to the appropriate position on the scale.

2-42 The bias is adjusted by DC ZERO potentiometer R61. It has a temperature-compensating diode D11 in series with it, which tends to hold the bias constant relative to the output transistor Q5 at changing temperatures.

2-43 Zener diode Z5 is part of the -18v power supply. Together with zener diode Z4 it sets a fixed voltage at the emitter of Q2.

NOTE

Photocells (PH1, PH2),(PH3, PH4) and lamps (L3, L4) are matched pairs selected at source. Therefore, when necessary, replacement of a matched pair must be made.

FEEDBACK AND METER CIRCUIT

2-44 The meter, M1, is connected in series with R67. R66 is connected between the balance point and the zener regulated -18 volt supply. The conditions under which the meter reads zero are such that the current drawn through the transistor, Q7, must be equal to the current that flows through R66. This is the zero point of the balance. Therefore, if an additional positive current flows through the transistor, current flows through R67 and the meter circuit, and the meter deflects positively to the relative scale position. Should the current be negative, the polarity of the meter is changed by the selection F1F and the meter then deflects in a clockwise direction indicating the magnitude of the negative measurement.

2-45 The feedback circuit is connected to the lower side of the meter at R68. The feedback is a function of the relationship between the voltage drop developed across R68 and the pi circuit for the particular measurement being made. The particular pi circuit is determined by the selection of both the FUNCTION and RANGE switches, and specifically wafers F2F, R2F, and R1B. These networks contain calibration potentiometers and fixed resistors. Cancellation of the input takes place at C14, and the feedback circuit may be defined as a potentiometric gain-adjust circuit.

PART 3
UNIT MAINTENANCE INSTRUCTIONS

PERFORMANCE CHECKS

3-1 The following procedure determines whether or not the unit is working normally. To check the accuracy of calibration of the unit, readings should be taken and compared to a standard. Proceed as follows:

(a) Move the FUNCTION switch to the +DCV position and the RANGE switch to the 1500 position.

(b) Operate the voltage selector, then connect the unit to the appropriate power source. Move the POWER switch to the ON position. Observe that the POWER ON light operates.

(c) Connect all test leads to the front panel of the unit.

(d) Connect the COM clip to the tip of the DCV probe.

(e) Turn the DC ZERO control to its maximum clockwise position and check that the meter pointer deflects at least 3% of full scale to the right.

(f) Turn the DC ZERO control to its maximum counter-clockwise position and move the FUNCTION switch to the -DCV position. Check that the meter pointer again deflects at least 3% of full scale to the right.

(g) Repeat steps (e) and (f) with the RANGE switch in the 0.015 (max ccw) position.

(h) Move the FUNCTION switch to the +DCA position and the RANGE switch to the 1.5 μa position. Connect the OHMS/MA test clip to the COM test clip.

(j) Turn the DC ZERO control to its maximum clockwise position and check that the meter pointer deflects at least 3% of full scale to the right.

(k) Turn the DC ZERO control to its maximum counter-clockwise position and the FUNCTION switch to the -DCA position. Check that the meter pointer again deflects at least 3% of full scale to the right.

(m) Repeat steps (h), (j) and (k) with the RANGE switch in the 150 ma position.

(n) Set the DC ZERO control for zero. See para 1-10 (d).

(p) Move the FUNCTION switch to the OHMS position and the RANGE switch to the R x 10 position. Check that the meter pointer deflects to the right.

(q) Turn the OHMS ADJUST control to the maximum counter-clockwise position and check that the meter pointer drops to at least 10% below full scale deflection.

(r) Turn the OHMS ADJUST control to the maximum clockwise position and check that the meter pointer deflects over full scale deflection to the right.

(s) Set the OHMS ADJUST control for full scale deflection and connect the OHMS test lead to the COM test lead. Check that the meter pointer reads ZERO.

(t) Repeat steps (q) and (s) on the R x 100, R x 1K, R x 10K, R x 100K, R x 1M and R x 10M positions of the RANGE switch.

(u) Connect the GROUND clip on the ACV probe to the probe tip. Move the RANGE switch to the 0.5 v range and the FUNCTION switch to the ACV position.

(v) After approximately 2 minutes warm-up, check that operating the AC ZERO control in the clockwise direction causes the meter pointer to deflect to the right, and that operating the control in the counter-clockwise direction causes the meter pointer to deflect to the left.

(w) Set the AC ZERO to Zero. Refer to para 1-11(d).

(x) Move the RANGE switch to the 500 v range and disconnect the GROUND clip from the probe tip.

(y) Measure the power line voltage, using only the probe tip. The meter pointer should deflect to the right and indicate the value of the power line voltage. Where the line voltage is below 150 vac, move the RANGE switch to the 150 v range and check that the value of line voltage indicated on this range matches that shown on the 500 v range within the specified tolerance of the instrument.

TROUBLE SHOOTING

3-2 The procedures by which faults within the multimeter can be isolated, are limited to symptoms which would be apparent during operation. The majority of the components are mounted on printed circuit boards and, since field servicing of these assemblies is not recommended, no attempt is made to predict a faulty component. Fault isolation is therefore limited to an electronic section of the equipment. See Fig. 3-1.

	Symptom	Probable Fault	Corrective Action
1	Power lamp does not light. Power connected and Power on switch (SW1) closed	Power supply off	Check power source and line cord connection
		Fuse F1 blown	Check power source. Check line cord and line cord connection. Replace F1.
		Power supply defective	Refer to Repair Procedures
		Power switch (SW1) or selector (SW2) defective	Replace switch SW1 or SW2
2	Meter does not register for any function. Power light on	Meter connections faulty	Remove wrap-around, inspect and if necessary repair connections to meter
		Faulty meter movement	Replace meter
3	Meter does not indicate on DC VOLTS only	Damaged test lead.	Check condition of test lead and DC VOLTS probe
		Faulty connection	Check panel connection
		Faulty FUNCTION switch	Refer to Repair Procedures

Fig. 3-1 Trouble Shooting Chart (Page 1 of 3)

	Symptom	Probable Fault	Corrective Action
4	Meter does not indicate on DCA only	Damaged test lead or faulty connection Faulty FUNCTION switch	Check condition of test lead and check panel connection Refer to Repair Procedures
5	Meter does not indicate on OHMS only	Incorrect setting of RANGE switch Test lead shorted between shield and centre conductor, or faulty connection Faulty OHMS ADJUST control or R34 open Broken wiring to OHMS ADJUST control Faulty FUNCTION switch	Check RANGE switch setting Check condition of test lead and check panel connection Refer to Repair Procedures. Remove wrap-around, inspect wiring, repair connection Refer to Repair Procedures
6	Meter does not indicate any resistance value. Pointer remains at full scale deflection	Test lead open circuit or faulty connection	Check condition of test lead and check panel connection
7	Meter does not indicate on AC VOLTS only	Damaged test lead or faulty connection Diode V1 in AC probe defective Faulty FUNCTION switch	Check condition of test lead and check connection Replace V1 Refer to Repair Procedure

Fig. 3-1 Trouble Shooting Chart (Page 2 of 3)

Fig. 3-1

	Symptom	Probable Fault	Corrective Action
8	DC ZERO control does not function	Faulty control, wiring, or component	Refer to Repair Procedure
9	OHMS ADJUST control does not function	Faulty control, wiring, or open resistor	Refer to Repair Procedure
10	AC ZERO control does not function. Meter deflects off scale to the left	Damaged test lead or faulty connection	Check condition of test lead and check panel connections
		Diode V1 in AC probe defective	Replace V1
		Faulty control, wiring or component	Refer to Repair Procedure
11	Meter indication does not compare with a standard on any one function	Out of calibration	Refer to Calibration Procedure

Fig. 3-1 Trouble Shooting Chart (Page 3 of 3)

PART 4
REPAIR, OVERHAUL AND CALIBRATION

GENERAL

4-1 This instrument is a complex unit and fault isolation and repair should not be undertaken without the proper tools, test equipment and facilities.

4-2 To repair and replace parts, follow specific instructions as laid down in this manual.

4-3 Fault analysis is divided into six sections as follows:

(a) Power supplies

(b) Chopper drive circuit

(c) Amplifier and input circuit

(d) Feedback circuit

(e) Switches and front panel controls

4-4 This division is an arbitrary one for ease of description only, since each section may affect one or more of the other sections. It is assumed that the trouble-shooting procedure in Part 3 has been followed and the fault has been established generally.

POWER SUPPLIES

4-5 To analyze faults within the power supplies the following equipment is required.

(a) Standard multimeter, 20,000 ohms per volt, capable of measuring ac volts, dc volts, dc amps and ohms.

(b) Standard screwdriver, medium blade.

4-6 The power supplies are located on the large printed circuit board, Part No. 152-2-11 mounted on the left side of the chassis, when viewed from the front of the unit. The printed circuit board contains 20 terminals which, in this procedure are numbered 1 through 20, commencing from the edge of the P.C.B. adjacent to the rear of the unit. Transformers T1 and T2 are mounted inside the chassis. Proceed as follows:

(a) Remove the nine screws which secure the wrap-around case.

(b) When the fault symptom is that the fuse blows when the power is turned on, remove the bottom panel of the unit, inspect and check power wiring, transformers and power switch before proceeding with further tests.

(c) Measure the voltages across the terminals of the printed circuit board and compare with the values given in Fig. 4-1.

CHOPPER DRIVE CIRCUIT

4-7 The chopper drive assembly is mounted on the amplifier assembly printed circuit board, located on the right side of the chassis when viewed from the front of the unit. Proceed as follows:

(a) Remove the wrap-around cover by removing the nine retaining screws.

(b) Using a multimeter, check that the voltage between pins 1 and 2 is 210 vdc.

(c) Using an oscilloscope, connect across L3 and then L4 and observe the waveshape. The presentation should be as shown in Fig. 4-2.

NOTE

When removing this board from the chopper block assembly, be careful to pull from between the two neon lamps and straight up so as not to twist them and possibly break leads.

Terminals	Voltage	Function
1 - 2	520 vac	Sec. T2
1 - 3	260 vac	Sec. T2
2 - 3	260 vac	Sec. T2
5 - 4	210 vdc	Chopper drive supply
6 - 7	6.5 vac	Sec. No. 1, T1
8 -18	-	-
9 -18	6.8 vdc	Amplifier supply
15-18	6 vdc	Probe filament supply
14-20	-18 vdc	Amplifier supply
16-17	18 vac	Sec. No. 2, T1

NOTE:

Terminals 18 and 19 are common -6.8 vdc
Terminal 20 is common +18 vdc

These voltages are nominal only and may vary as much as 10% from unit to unit.

Fig. 4-1 Power Supply Voltages

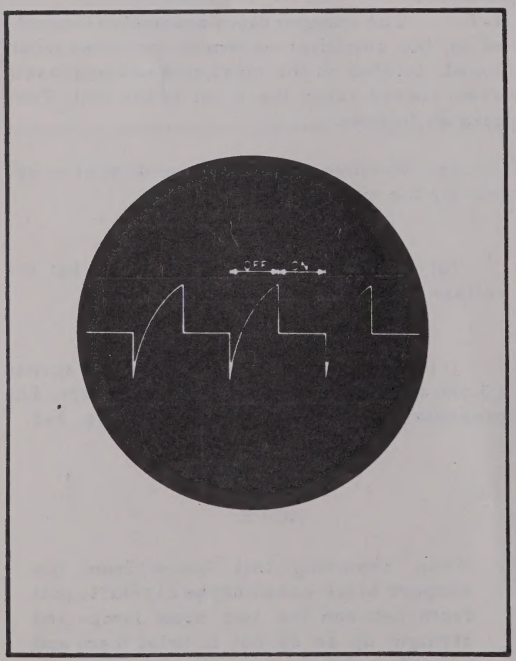


Fig. 4-2 Waveform Across L3 and L4

AMPLIFIER

4-8 The amplifier circuit board is mounted on the right side of the chassis when viewed from the front of the unit as follows:

(a) Using a VTVM with at least 11 megohms input impedance, measure the voltages across the transistors as indicated in Fig. 4-3.

(b) Note that if unable to set DC ZERO, the fault could be in photo cells PH1, PH2, PH3, or PH4. A defective photocell will unbalance the circuit and cause the meter reading "off zero". Should DC ZERO control be ineffective, check diode D11.

FEEDBACK CIRCUIT

4-9 Most of the feedback circuit is located on the calibration board. The components are all resistive. Possible faults are open circuited or short circuited resistors or broken wire. Replace, repair and re-calibrate as necessary.

Transistor	Gate	Source	Drain
Q1	- 4	- 6	- 8 vdc
Transistor	**Emitter**	**Base**	**Collector**
Q2	- 9	- 8	- 6 vdc
Q3	- 0.3	- 0.45	- 3 vdc
Q4	- 2.8	- 3	- 8.5 vdc
Q5	+ 4.5	+ 4.3	- 6.5 vdc
Q6	+ 0.62	+ 1	+ 6 vdc
Q7	0	+ 0.62	+ 6 vdc

NOTE

Above voltages are measured with respect to COMMON pin pins 5, 6 and 10

Fig. 4-3 Amplifier Voltage Check

NOTE

Should it be necessary to replace any component in this circuit, the unit must be re-calibrated.

SWITCHES AND
FRONT PANEL CONTROLS

4-10 Switches are ceramic and quite delicate; therefore mounting the assembly in a jig for repair is recommended. Proceed as follows:

(a) To replace a resistor, cut the leads of the faulty resistor.

(b) Pre-cut the leads of the replacement resistor and bend them. The lead should be slightly hooked.

(c) Apply the soldering iron to the tab and remove the end of the old lead.

(d) Apply the iron to the tab; insert the lead of the replacement resistor and re-solder. Repeat for the other end.

REPLACEMENT OF COMPONENTS

4-11 The procedure for replacing components, reference Fig. 4-4, is as follows:

(a) Hold the board in either the vertical or horizontal position with the printed side down. Apply heat sparingly to the lead of the component to be removed from printed side of board. (Use a well-tinned soldering iron.)

(b) Remove the component from the board one lead at a time. It may require heating the leads alternately and "wiggling" the component out of the board.

(c) Reheat the solder in the hole and allow as much solder as possible to adhere to the soldering iron. Immediately insert an awl into the hole from the printed side to clean out the hole. This procedure should be followed carefully or extensive damage to the printed circuit board will result.

(d) For many-leaded items, heat one lead at a time and withdraw the lead as far

as possible. Repeat this procedure for remaining leads in sequence until the component is "wiggled" loose.

(e) Bend the clean, tinned leads of new component and carefully insert them in the holes. (Do not force the component. If the leads do not insert easily, reheat the pad and clean the holes as described in step (c).)

(f) Hold the part against the board and solder the leads from the printed side of the board. Do not leave a large quantity of solder on the pad. The ideal amount can be determined by observing the other connections made during production.

CALIBRATION PROCEDURES

4-12 All calibration points are located on the printed circuit board on top of the chassis. See Fig. 4-5.

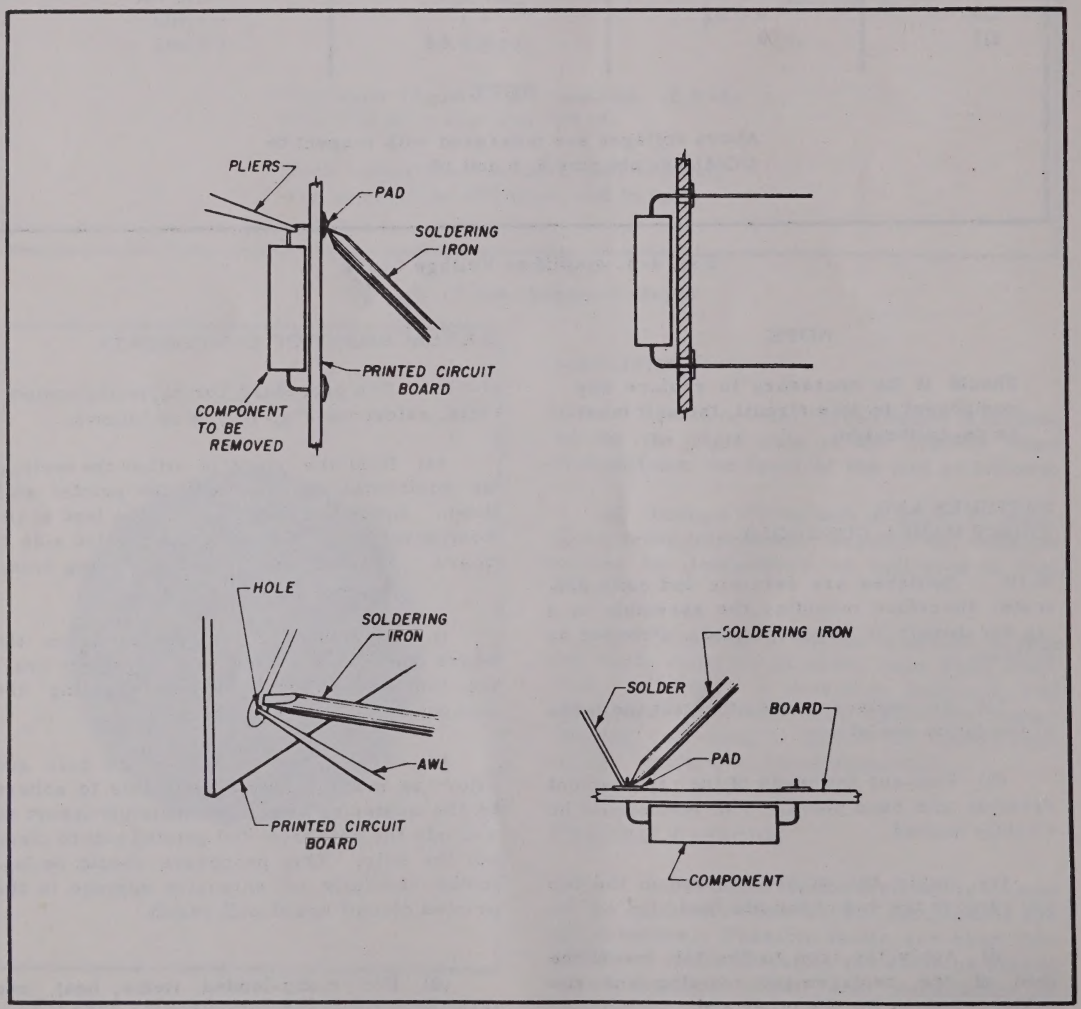


Fig. 4-4 Servicing Etched Circuit Boards

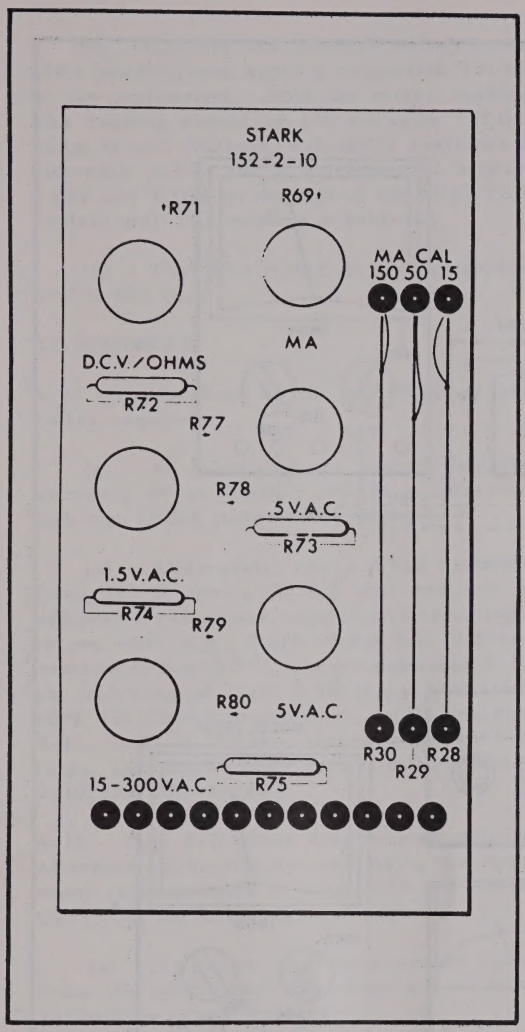


Fig. 4-5 Calibration Circuit Board Location Diagram

DC VOLTS

4-13 Calibration of the dc volts circuitry requires:

(a) A calibrated source of dc voltage with an accuracy of at least 0.25% (e.g., Harrison Lab type 6920B) and a decade voltage divider with an accuracy within at least 0.1% (e.g., General Radio type 1454-A).

(b) Alternately a regulated adjustable dc voltage supply with line voltage regulation and ripple less than 10 millivolts peak-to-peak is acceptable (e.g., Stark PS501A or PS503) together with a decade voltage divider with an accuracy within at least 0.1% (e.g., General Radio type 1454-A) and an accurate voltmeter 0-150v ± 0.5%, (e.g., Yew Type 121158).

4-14 Fig. 4-6 shows diagrammatically the alternate calibration set-ups using the equipment recommended in steps (a) and (b). Carry out the following procedure:

(a) Remove the wrap-around cover from the multimeter to provide access to the calibration potentiometers.

(b) Operate all equipment in accordance with the procedures recommended in the appropriate operating manuals. Ensure that the FUNCTION switch of the multimeter is in the +DCV position and the RANGE switch is in the 0.015 volt position.

(c) Allow at least two minutes warm-up prior to making any adjustments to ensure that the unit is stabilized.

(d) Connect the COM test lead clip to the tip of the DC VOLT probe. Check, and if necessary, adjust the DC ZERO control.

NOTE

DC ZERO is properly adjusted when the action of switching the FUNCTION switch from +DCV to -DCV does not alter the final position of the meter pointer. This position should coincide with the zero line on the meter dial. If not, then it is likely that the meter zero adjust screw requires re-setting.

(e) Connect the equipment in accordance with the test set-up, Fig. 4-6, and operate the RANGE switch to the 1500 volt position.

(f) Disconnect the COM test clip from the DC VOLT probe and apply a calibrated 12 millivolts dc signal to the instrument. Turn the RANGE switch to the 0.015 volt position and note the meter reading. The reading should be 12 ± 0.3 millivolts. Adjust potentiometer R71 (DCV/OHMS) until this value is obtained.

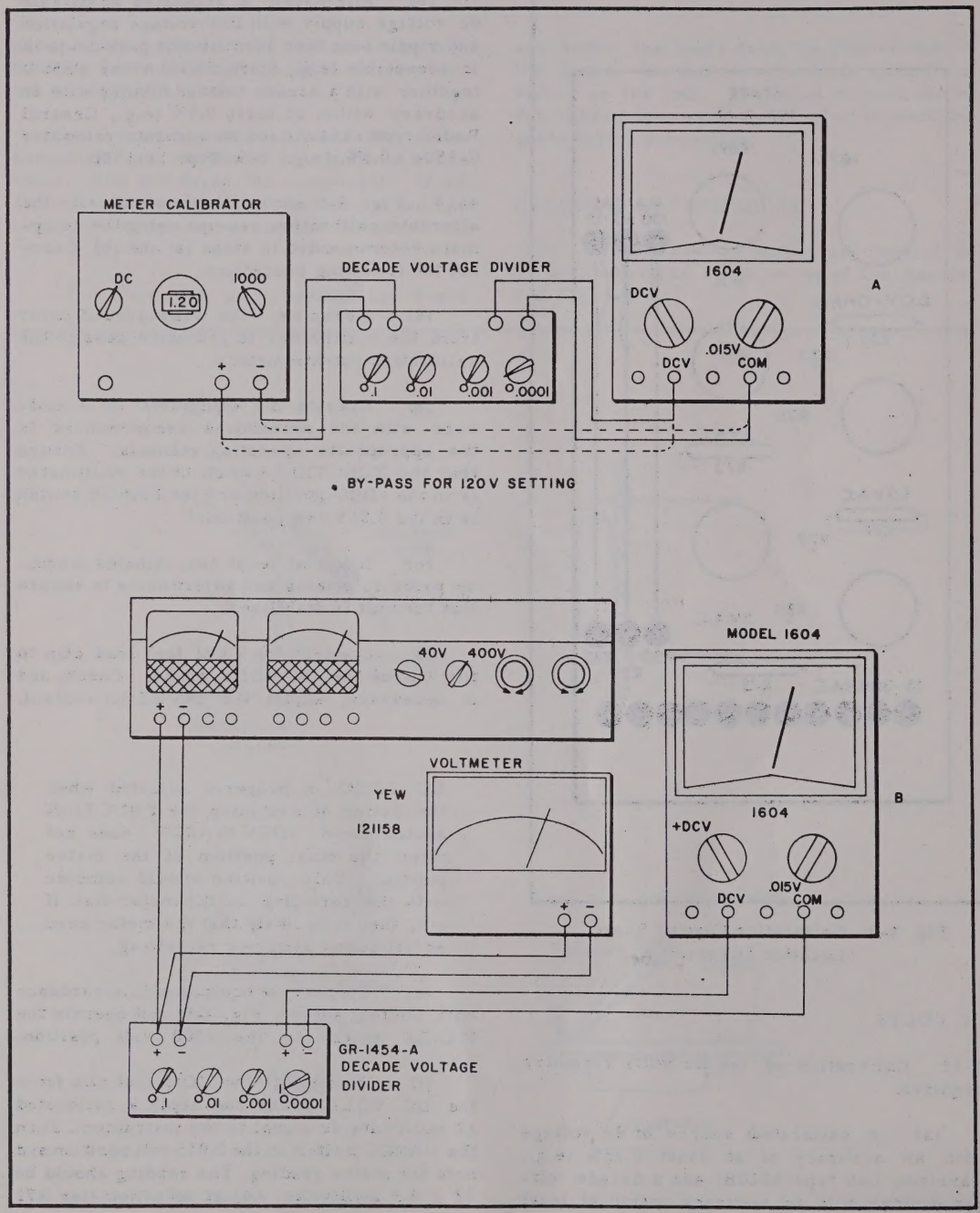


Fig. 4-6 Test Set-Up for Calibration of DC Volts Circuitry

(g) Operate the RANGE switch to the 150 v position and apply a calibrated 120 vdc to the instrument. Note the meter reading. The reading should be 120 ± 3 volts. If this value is not obtained, substitute resistors of alternate values for R12 (connected between F3B1 and F3B2 on the side of the FUNCTION switch) until this reading is achieved.

(h) The multimeter is now calibrated on DC VOLTS.

DC AMPERES

4-15 Calibration of the dc amperes circuitry requires:

(a) A calibrated dc source with an accuracy of at least 0.25% (e.g., Harrison Lab type 6920A Meter Calibrator.)

(b) Alternately, use a 6 volt battery; a fixed 100 K ohm ± 5%, 0.5 watt resistor; an adjustable resistance capable of dissipating up to one watt (e.g., Stark Model RD-10 decade resistance box (0.5%); a microammeter, 0-100 μa, accuracy at least 0.5% (e.g., Yew Model MPF 121105 microammeter); a milliammeter, 0-15, 0-50, 0-150 ma, accuracy at least 0.5% (e.g., Yew Model MPF 121138 milliammeter, 0-30/100/300 ranges).

4-16 Fig. 4-7 shows diagrammatically the alternate calibration set-ups, using the equipment recommended in para 4-15 (a) and (b). Carry out the following procedure:

(a) Remove the wrap-around cover from the multimeter to provide access to the calibration potentiometers.

(b) Operate all equipment in accordance with the procedures recommended in the appropriate operating manuals. Ensure that the FUNCTION switch of the multimeter is in the +DCA position and the RANGE switch is in the 50 microampere position.

(c) Allow at least two minutes warm-up prior to making any adjustments to ensure that the unit is stabilized.

(d) Connect the COM test lead clip to the DCA/OHMS test lead clip. Check, and if necessary, adjust the DC ZERO control.

NOTE

DC ZERO is properly adjusted when the action of switching the FUNCTION switch from +DCA to -DCA does not alter the final position of the meter pointer. This position should coincide with the zero line on the meter dial. If it does not, then it is likely that the meter zero-adjust screw requires re-setting.

(e) Disconnect the COM and DCA/OHMS test leads. Connect the equipment in accordance with the appropriate test set-up, Fig. 4-7. Move the RANGE switch to the 150 ma position.

(f) Apply a calibrated current of 40 microamperes dc to the instrument. Operate the RANGE switch to the 50 μa position and note the meter reading. The reading should be 40 ± 1.5 microamperes. Adjust potentiometer R69 (MA CAL) until this value is obtained.

(g) Operate the RANGE switch to the 150 ma position.

(h) Apply a calibrated current of 120 milliamperes dc to the instrument and note the meter reading. The reading should be 120 ± 4.5 milliamperes. If this value is not obtained, using a soldering iron, adjust the sliding contact on R30 (150 MA CAL) until the reading is achieved.

NOTE

When making this adjustment it should be remembered that the application of heat from the soldering iron will cause an increase in resistance. Thus, to ensure that a final setting has been reached, readings should not be taken until after the joint between the contact and the resistance wire has cooled.

(j) Apply a calibrated current of 40 ma to the instrument and operate the RANGE switch to the 50 ma position. Note the meter reading. The reading should be 40 ± 1.5 ma. If this value is not obtained, using a soldering iron, adjust the sliding contact on R29 (50 MA CAL) until the reading is achieved.

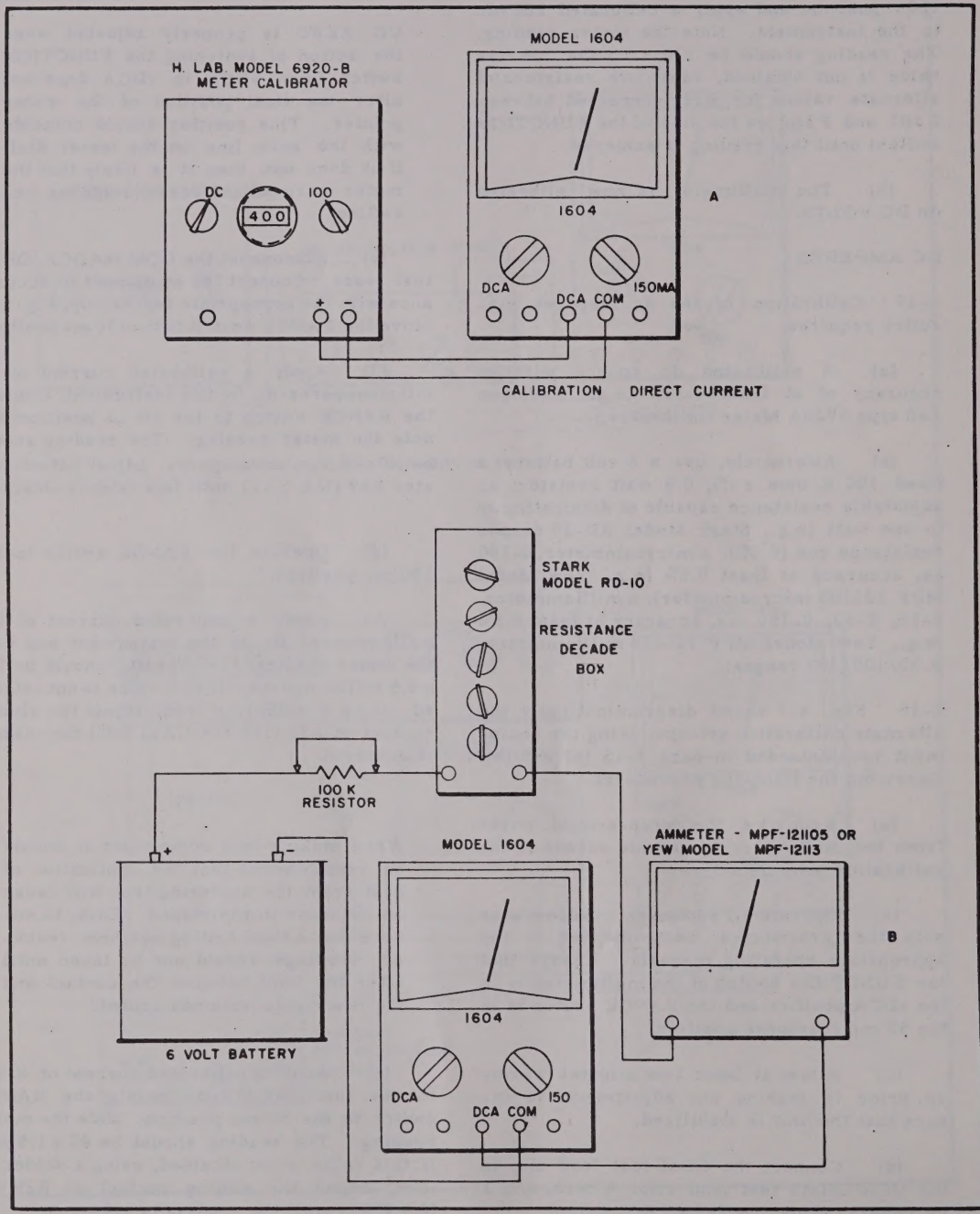


Fig. 4-7 Test Set-Up for Calibration of DC Amperes Circuitry

(k) Apply a calibrated current of 12 ma to the instrument. Operate the RANGE switch to the 15 ma position and note the meter reading. The reading should be 12 ± 0.45 ma. If this value is not obtained, using a soldering iron, adjust the sliding contact on R28 (15 MA CAL) until the reading is achieved

(m) Recheck, and if necessary, readjust the settings in steps (h), (j) and (k).

(n) The instrument is now calibrated for direct current measurement.

AC VOLTS

4-17 Calibration of the ac volts circuitry requires:

(a) A calibrated ac voltage source (400 cps) with an accuracy of at least 0.25% (e.g., G and E Bradley Model 125B, or Hewlett-Packard Model 738AR).

(b) Alternatively use a low frequency signal generator, capable of at least 15 v rms output with harmonic distortion less than 1% (e.g., Hickock Model 2975M); a decade voltage divider with an accuracy of at least 0.1%, (e.g., General Radio 1454-A); an ac voltmeter, 1000 ohms/volt, 0-15 volts. Accuracy at least 0.5% (e.g., YEW SPF 122153).

4-18 Fig. 4-8 shows diagrammatically the alternate calibration set-ups using the equipment recommended in para 4-17 (a) and (b). Proceed as follows:

(a) Remove the wrap-around cover from the multimeter to provide access to the calibration potentiometers.

(b) Operate all equipment in accordance with the procedures recommended in the appropriate operating manuals. Ensure that the FUNCTION switch is in the +DCV position and the RANGE switch is in the 0.015 v position.

(c) Allow at least a two minute warm-up prior to making any adjustments to ensure that the unit is stabilized.

(d) Check, and if necessary, adjust the DC ZERO control as described in para 4-14 (d).

NOTE

It is essential that the DC ZERO be adjusted properly prior to proceeding with the ac volts calibration. Failure to do so could result in errors up to 3% FSD.

(e) Connect the ground clip on the AC VOLTS probe to the probe tip. Operate the FUNCTION switch to ACV and the RANGE switch to the 0.5 volt range.

(f) Allow 15 minutes warm-up for the tube in the probe, prior to making any further adjustments.

(g) Adjust the AC ZERO control on the front panel until the meter pointer rests on the zero line on the meter scale.

(h) Disconnect the ground clip from the probe tip and operate the RANGE switch to the maximum clockwise position. Connect the equipment in accordance with the appropriate test set-up, Fig. 4-8.

(j) Apply a calibrated input of 0.4 vac, 400 cps to the unit. Operate the RANGE switch to the 0.5 vac range and note the meter reading. The reading should be 0.4 ± 0.15 vac.

NOTE

On the 0.5 and 1.5 vac range readings are taken on the two middle non-linear scales (red). All others are read on the upper linear scales (black).

(k) If the reading in step (j) is not obtained, adjust potentiometer R77 (0.5 vac CAL) until the value is achieved.

(m) Operate the RANGE switch to the 1.5 vac range and apply a calibrated input of 1.2 vac, 400 cps to the unit. Note the meter reading. The reading should be 1.2 ± 0.045 v. If the reading is not obtained, adjust potentiometer R78 (1.5 vac CAL) until the value is achieved.

(n) Operate the RANGE switch to the 5 vac range and apply a calibrated input of 4 vac, 400 cps to the unit. Note the meter reading. The reading should be 4 ± 0.15 vac.

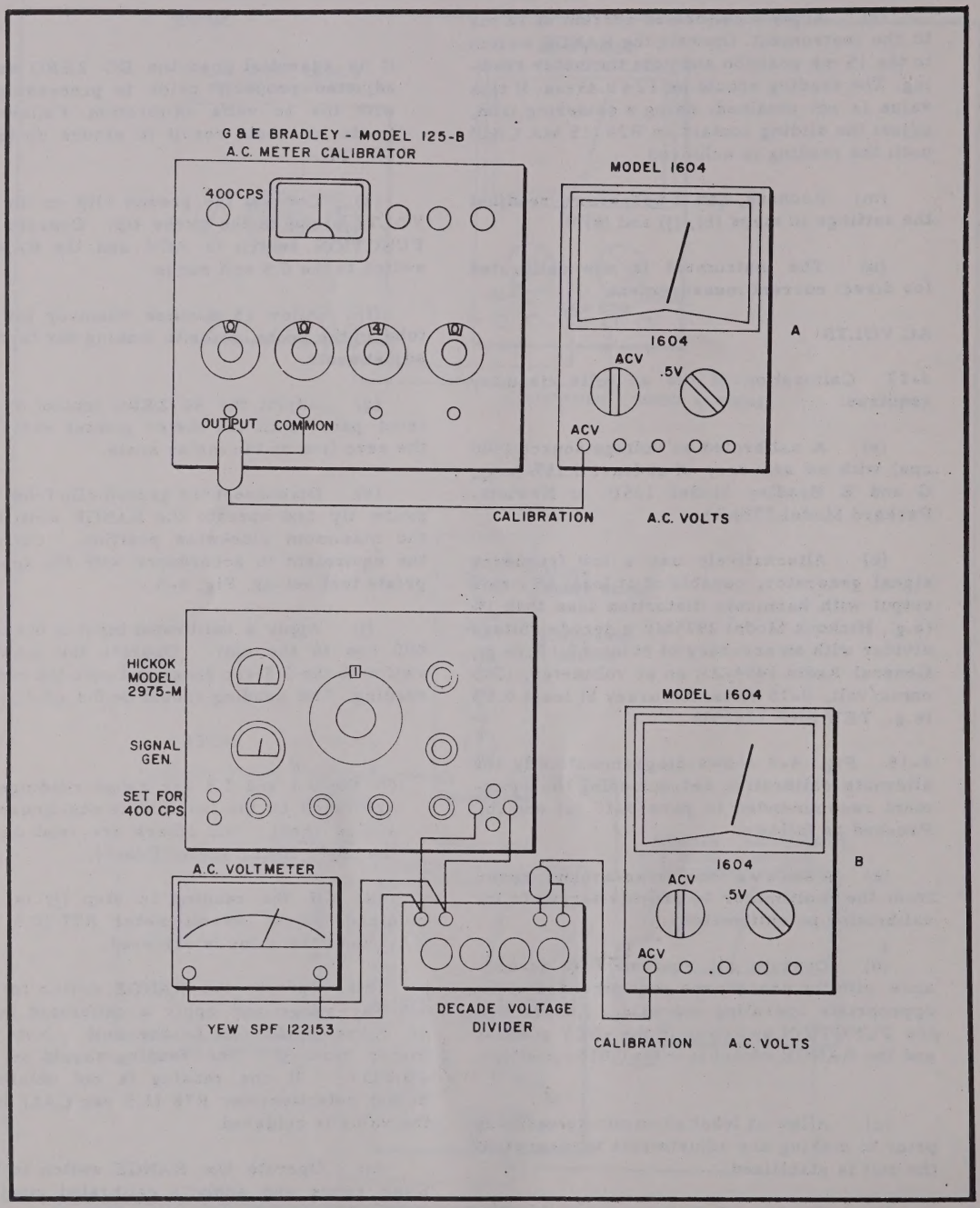


Fig. 4-8 Test Set-Up for Calibration of AC Volts Circuitry

If the reading is not obtained, adjust potentiometer R79 (5 vac CAL) until the value is achieved.

(p) Operate the RANGE switch to the 15 vac range and apply a calibrated input of 12 vac, 400 cps to the unit. Note the meter reading. The reading should be 12 ± 0.45 vac. If the reading is not obtained, adjust potentiometer R80 (15 - 300 vac CAL) until the value is achieved.

(q) The instrument is now calibrated to measure ac voltage.

CHOPPER DRIVE FREQUENCY

4-19 This frequency is normally set at the factory, but should be checked after replacement of any component in the chopper power supply or on chopper drive circuit board assembly. The equipment required is a general purpose oscilloscope (e.g., Stark OSK2) and an audio frequency generator (e.g., Stark LAG55). The test set-up is shown diagrammatically in Fig. 4-9. Proceed as follows:

(a) Remove the wrap-around cover from the multimeter.

(b) Remove the outer shield from the chopper block.

(c) Turn on the equipment. Ensure that the multimeter ground plug is in normal (ground) position.

(d) Operate the sweep selector on the oscilloscope to the external sweep position.

(e) Connect the audio generator outputs to the horizontal input on the oscilloscope.

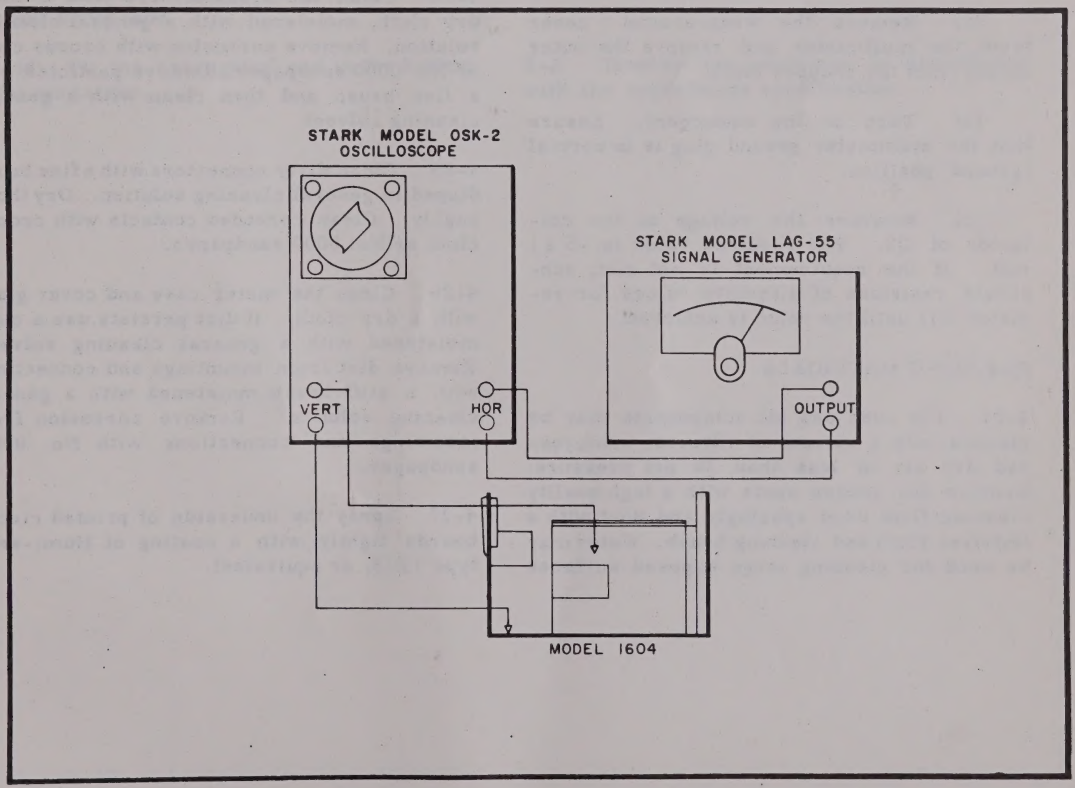


Fig. 4-9 Test Set-Up for Calibration of Chopper Drive Circuitry

(f) Connect the vertical input across L3 or L4 on the chopper drive board with the ground lead connected to the chassis.

(g) Vary the frequency of the audio generator until a single stationary lissajous figure appears. Note the frequency. It should be 70 to 85 cps. If this value is not obtained, substitute capacitors of different values for capacitor, C8, until the desired frequency is achieved.

AMPLIFIER (Q1) BIAS

4-20 The bias is normally set at the factory but should be checked after replacement of Q1 or Q2. The equipment required is a general purpose VTVM, 2 or 3% (e.g., Stark VMK4, VMK3, or a multimeter, model 1604). Proceed as follows:

(a) Remove the wrap-around cover from the multimeter and remove the outer shield from the chopper block.

(b) Turn on the equipment. Ensure that the multimeter ground plug is in normal (ground) position.

(c) Measure the voltage at the collector of Q2. The required value is -5 ± 1 volt. If the requirement is not met, substitute resistors of alternate values for resistor R41 until the value is achieved.

CLEANING MATERIALS

4-21 The case and all components may be cleaned with a stream of filtered, compressed dry air of less than 30 psi pressure. Remove any grease spots with a high quality cleaning fluid used sparingly and dust with a lint-free cloth and cleaning brush. Water may be used for cleaning large exposed surfaces where evaporation can readily take place. For general cleaning purposes the following mixed solution is recommended: 70 percent dry cleaning solvent (Federal Specification P-S-661), 5 percent trichlorethylene (Federal Specification O-T-236) and 25 percent methylene chloride (Air Force Specification AN-M-37).

4-22 It is advisable that chassis parts be disturbed as little as possible. Generally, clean only with compressed air. Do not move parts during cleaning and do not score chassis surfaces.

4-23 Clean exterior surfaces of fixed capacitors with a general cleaning solution and a soft brush. Clean exterior surfaces with a soft cloth moistened with a general cleaning solvent. (Refer to para 4-21).

4-24 Clean the transformers with a clean dry cloth, moistened with a general cleaning solution. Remove corrosion with crocus cloth or No. 0000 sandpaper. Remove particles with a fine brush and then clean with a general cleaning solvent.

4-25 Clean dirty connectors with a fine brush dipped in general cleaning solution. Dry thoroughly. Clean corroded contacts with crocus cloth or No. 0000 sandpaper.

4-26 Clean the meter case and cover glass with a dry cloth. If dirt persists use a cloth moistened with a general cleaning solvent. Remove dirt from mountings and connections with a stiff brush moistened with a general cleaning solution. Remove corrosion from mountings and connections with No. 0000 sandpaper.

4-27 Spray the underside of printed circuit boards lightly with a coating of Humi-seal, type 1B15, or equivalent.

PART 5
PACKAGING, PRESERVATION AND STORAGE

PACKAGING

5-1 The multimeter and test leads are packaged in a corrugated carton adequately protected by folded corrugated wedges. To pack the unit, proceed as follows:

(a) Disconnect the test leads from the front panel, coil and tape them.

(b) Place the leads in individual plastic bags.

(c) Secure the ground plug on the rear of the unit using tape.

(d) Fit the corrugated pad in the bottom of the container.

(e) Seal the unit in a vapour barrier together with desiccant and place it in the corrugated cardboard container.

(f) Place the corrugated wraparound around the unit. Insert the two corrugated side pads and the two corrugated end wedges between the unit and the wraparound.

(g) Insert the four corner wedges to locate the unit rigidly.

(h) Insert the test leads within the side packages. Place the top corrugated pad over the unit and seal the box.

5-2 Identify the container in accordance with the appropriate specification.

PART 6
PART LIST

INTRODUCTION

6-1 This part list describes and illustrates the items necessary to support the Electronic Multimeter, Model 1604M, manufactured for Hickok by Stark Electronic Instruments Limited, Ajax, Ontario.

6-2 The purpose of this part list is to assist supply, maintenance and overhaul personnel in identifying, requistioning, issuing and storing replaceable parts of the equipment.

6-3 Abbreviations used throughout this part list are in compliance with Military Standard MIL-STD-12.

Abbreviations	Term
alum.	aluminum
comp	composition
cps	cycles per second
c/w	complete with
dia	diameter
dep	deposit
fil	fillister
int	internal
mtg	mounting
Spec Cont Drawing	Specification Control Drawing
vac	alternate current volts
vdc	direct current volts
vdcw	direct current working volts

Fig. 6-1 List of Abbreviations

GROUP ASSEMBLY PART LIST

6-4 The group assembly part list, consists of a breakdown parts list in order of disassembly, separated into figures by assemblies. The parts listed, are in most cases, keyed to associated illustrations by figure and index numbers and are listed in disassembly sequence except where the sequence of disassembly does not apply.

FIGURE AND INDEX NUMBER COLUMNS

6-5 The first two numbers listed in this column of the group assembly part list represent the figure number of the illustration in which the corresponding part is shown. The third number, following the hyphen is the index number used, where applicable, to relate the part in the illustration with the part number and nomenclature in the text. Where an assembly or detail part has not been assigned an index number, only the figure number is shown for the part.

PART NUMBER COLUMN

6-6 The numbers in this column are primarily grovernment standard numbers, Stark part numbers, or vendor part numbers where available.

VENDOR PART NUMBERS

6-7 Vendor part numbers are used to identify parts manufactured by a contractor other than Stark Electronic Instruments Limited. The vendor number, when available, appears in the part number column. If no vendor number has been assigned, a "No Number" entry appears in the part number column of the group assembly part list and the Stark specification number is shown at the end of the description. Where there is no vendor part number, the control drawing specification is listed.

NOMENCLATURE COLUMN

6-8 This column contains the complete nomenclature of each item, properly arranged, in accordance with the specification. It is based on Stark's drawing title, plus any technical data not shown as part of the drawing title which is necessary to completely identify that particular item. The nomenclature column for commercial parts include the type, model specifications and the name of the design manufacturer. The nomenclature column for commercial hardware includes such identifying information as size, material and type.

6-9 The identifying noun is the first word of the nomenclature. If the part is an assembly, the word "Assembly" immediately follows the noun. This is followed by a dash (-) and by the descriptive part of the nomenclature.

6-10 When an item has been assigned a reference designation, that designation appears in parenthesis immediately following the descriptive nomenclature. For future assignments ( ), are provided. This is followed by the vendor code, where applicable, in parenthesis, followed by the Stark specification number, also in parenthesis.

VENDOR CODES

6-11 Where available from drawing sources, the vendor's identification code appears parenthetically at the end of the part description. If no code has been authorized, the vendor name and address is listed. All codes are in accordance with the Federal Supply Code for Manufacturers, Cataloging Handbook H4-1 and H4-2.

STARK SPECIFICATION NUMBERS

6-12 On many items manufactured by contractors other than Stark Electronic Instruments Limited, specification control is retained by Stark. All required specifications of a part are listed in a single document which is assigned a specification control number. This number is shown within a parenthetical note following the vendor code; for example, (Spec Cont Dwg 112-7-22).

Designation	Manufacturer or Representative	Address
01295	Texas Instruments Inc., Component Division.	Dallas, Texas
02660	Amphenol-Borg Electronics Corp.	Maywood, Ill.
03554	Amphenol Canada Limited	Toronto, Ontario.
09746	Ward Leonard of Canada Ltd.	Toronto, Ontario
11236	CTS of Canada Ltd.	Streetsville, Ontario.
12287	Canadian Stackpole Ltd,	Toronto, Ontario
12294	Erie Technological Products of Canada Limited	Trenton, Ontario
35009	International Resistance Corp.	Toronto, Ontario
35388	Griffith G. L. and Sons Ltd.	Stratford, Ont.
35784	Philips Electronics Industries Ltd.	Toronto, Ont.

Fig. 6-2 List of Manufacturers (Page 1 of 2)

Designation	Manufacturer or Representative	Address
35929	Contana of Canada Ltd.	Montreal, P.Q.
36002	Welwyn Canada Ltd.	London, Ontario
36204	Philips Industries Limited, Div. of Philips Electronics Industries Limited	Toronto, Ontario
37942	Mallory P.R. and Co. Inc.	Indianapolis Ind.
56289	Sprague Electric Co.	North Adams, Mass.
70903	Belden Mfg. Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis
72653	G. E. Electronics Mfg. Co.	Rockford, Ill.
75915	Littlefuse Inc.	Des Plaines, Ill.
76545	Mueller Elec. Co.	Cleveland, Ohio.
77251	Philadelphia Hardware and Malleable Iron Works	Philadelphia, Pa.
78189	Shakeproof Div. of Illinois Tool Works	Elgin, Ill.
78947	Ucinite Co. The Div. of United-Carr Inc.	Newtonville, Mass.
79727	Continental-Wirt Electronics Corp.	Philadelphia P.A.
80058	Joint Electronic Type Designation System	
81349	Military Specifications promulgated by Standardization Div. Directorate of Logistic Services PSA	
82389	Switchcraft Inc.	Chicago, Ill.
84970	Sarkes Tarzian Inc.	Bloomington Ind.
87930	Tower Mfg. Co.	Providence R.I.
94139	Keystone Electronics Co.	Newark, N.J.
94223	Spae Naur Products Co.	Kitchener, Ontario
95800	Stark Electronic Instruments Ltd.	Ajax, Ontario
96924	Grigsby Co.	Washington, D.C.

Fig. 6-2 List of Manufacturers (Page 2 of 2)

6-13 The number assigned to a part by the manufacturing contractor is the number shown in the part number column of the group assembly part lists.

ATTACHING PARTS

6-14 Attaching parts are listed in the same indent and immediately following the item(s) to be attached. When the item to be attached is an assembly or subassembly the components of that assembly or subassembly are listed between the separating symbol "---*---" and are indented to show correct relationship to their assembly which appears above the caption "ATTACHING PARTS". The quantity listed in the units per assembly column indicates the quantity required for attaching a single part.

ITEMS NOT LISTED

6-15 Bulk items such as electrical wiring or cabling, vinyl tubing, and sleeving are not listed. Parts which lose their identity by being soldered, brazed, welded, riveted, swaged, cemented, sealed, or otherwise attached to other parts or assemblies in such manner as to be permanent, and not subject to disassembly are not listed in the part list.

UNITS PER ASSEMBLY COLUMN

6-16 Listings in this column indicate the quantity of parts required per assembly. Abbreviation AR (as required) indicates that the quantity is determined by the specific requirements of that component.

GROUP ASSEMBLY PART LIST

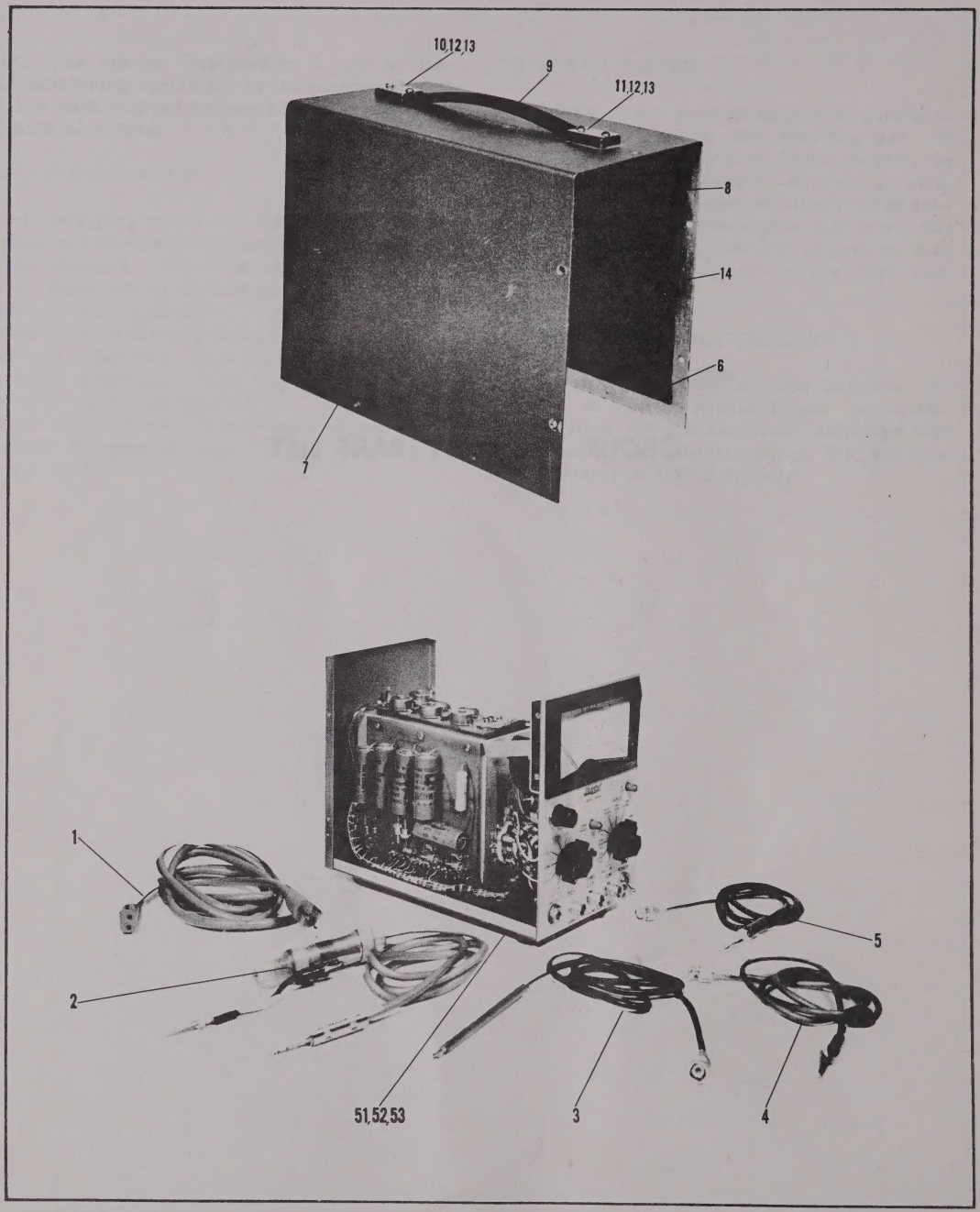


Fig. 6-3 Electronic Multimeter, 1604M (Page 1 of 3)

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
	GROUP	ELECTRONIC MULTIMETER, 1604M			
	MAJOR ASSEMBLY	ELECTRONIC MULTIMETER, 1604M			
6-3		100-00-374	Multimeter - Electronic, 1604M (F.S.N. 6625-168-0503) (95800)	Ref	
- 1		No Number	Cord - Line, 3 conductor, 18 ga, 6 ft. SJT c/w male and female moulded ends (95800) (Spec Cont Dwg 111-2-23)	1	
- 2		151-7-11	Test Lead Assembly - AC Probe (95800) (See Fig. 6-4 for breakdown)	1	
- 3		151-7-12	Test Lead Assembly - DC Volts (95800) (See Fig. 6-5 for breakdown)	1	
- 4		151-7-14	Test Lead Assembly - OHMS/DCA (95800) (See Fig. 6-5 for breakdown)	1	
- 5		151-7-13	Test Lead Assembly - COM (95800) (See Fig. 6-5 for breakdown)	1	
- 6		No Number	Cabinet - Wrap-around (95800)	1	
			ATTACHING PARTS		
- 7		143-4-6	Screw - Machine, fil head, No. 4-40, 1/4 in. lg. steel, ni pl. (95800)	9	
			---*---		
- 8		104-1-87	Bracket - Panel brace, 0.062 in. alum. (95800)	1	
- 9		7820	Handle - Black, 7-1/2 in. lg. (77251) (Spec Cont Dwg 118-5-18)	1	
			ATTACHING PARTS		
-10		143-6-10	Screw - Machine, rd hd, No. 6-32, 1/2 in. lg., steel, ni pl (95800)	2	
-11		143-6-16	Screw - Machine, rd hd, No. 6-32, 5/8 in. lg., steel, ni pl (95800)	2	
-12		153-9-96	Washer - Lock, No. 6, internal, steel, ni pl (95800)	4	
-13		127-6-9	Nut - Hexagon, No. 6-32, steel, ni pl (95800)	4	
			---*---		
-14		No Number	Cabinet - Painted (95800) Part No. 107-9-83		
-15		161-1-63	Meter - NH movement, taut-band suspension; Model 88 case; 0.5 ma shunted to 1 ma with copper resistor (M1) (95800)	1	
			ATTACHING PARTS		
-16		143-6-7	Screw - Machine, rd hd, No. 6-32, 1/4 in. lg. steel, ni pl (95800)	2	
			---*---		

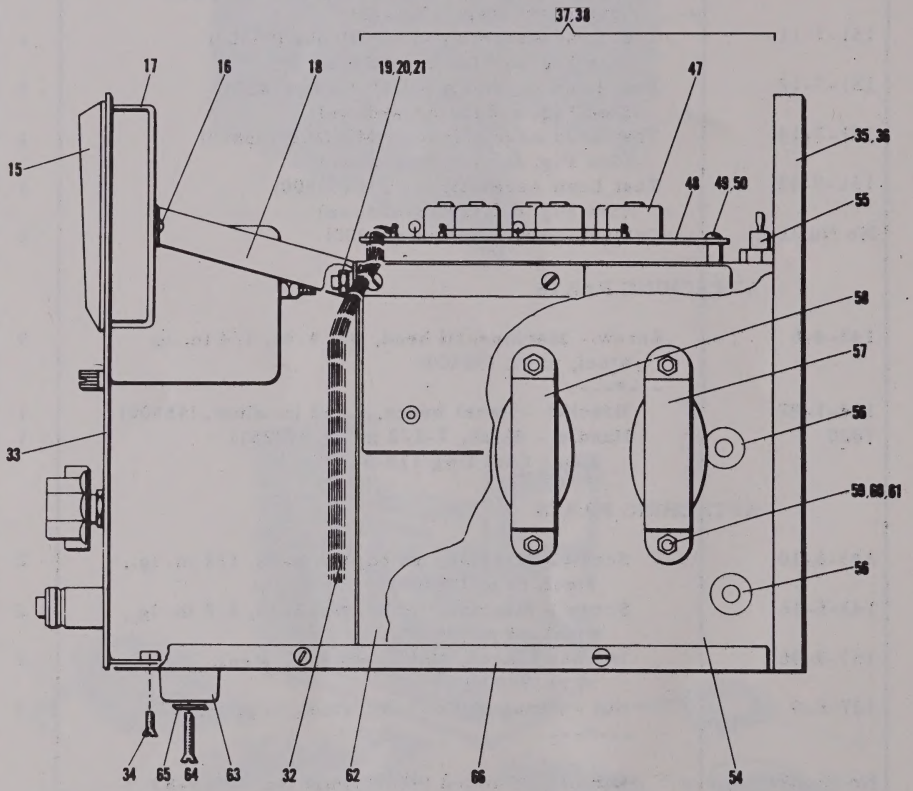


Fig. 6-3 Electronic Multimeter, 1604M (Page 2 of 3)

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
	GROUP		ELECTRONIC MULTIMETER, 1604M		
	MAJOR ASSEMBLY		ELECTRONIC MULTIMETER, 1604M (Cont'd)		
6-3					
-17		104-1-84	Bracket - Meter mounting (95800)	2	
-18		104-1-85	Bracket - Support (95800)	1	
			ATTACHING PARTS		
-19		127-6-9	Nut - Hexagon, No. 6-32, st, ni pl (95800)	I	
-20		153-9-96	Washer - Lock, int. No. 6 st, ni pl (95800)	1	
-21		153-2-23	Washer - Flat, No. 6 st, ni pl (95800)	1	
			---*---		
-22		145-5-79	Shield - Input, chopper block assembly (95800)	1	
			ATTACHING PARTS		
-23		143-4-113	Screw - Machine, binding head, 4-40, 1/2 in. lg. steel, ni pl (95800)	3	
-24		115-6-75	Spacer - Phenolic, insulation, 5/16 in. od, 5/32 in id, 3/16 in. lg. (95800)	1	
-25		W74F	Washer - Shoulder, fibre, No. 4 hole (94223) (Spec Cont Dwg 153-05-101)	1	
			---*---		
-26		152-2-15	Input Circuit Assembly (95800) (See Fig. 6-6 for breakdown)	1	
			ATTACHING PARTS		
-27		143-4-113	Screw - Machine, binding head, 4-40, 1/4 in. lg. steel, ni pl (95800)	1	
			---*---		
-28		152-2-9	Chopper Drive Assembly (95800) (See Fig. 6-7 for breakdown)	1	
			ATTACHING PARTS		
-29		143-4-20	Screw - Machine, rd hd, 4-40, 1 in. lg. steel, ni pl (95800)	1	
-30		153-2-22	Washer - Flat, No. 4, brass, ni pl (95800)	1	
			---*---		
-31		145-5-83	Shield - Chopper drive assembly, brass (95800)	1	
-32		165-1-33	Harness Assembly (95800)	1	

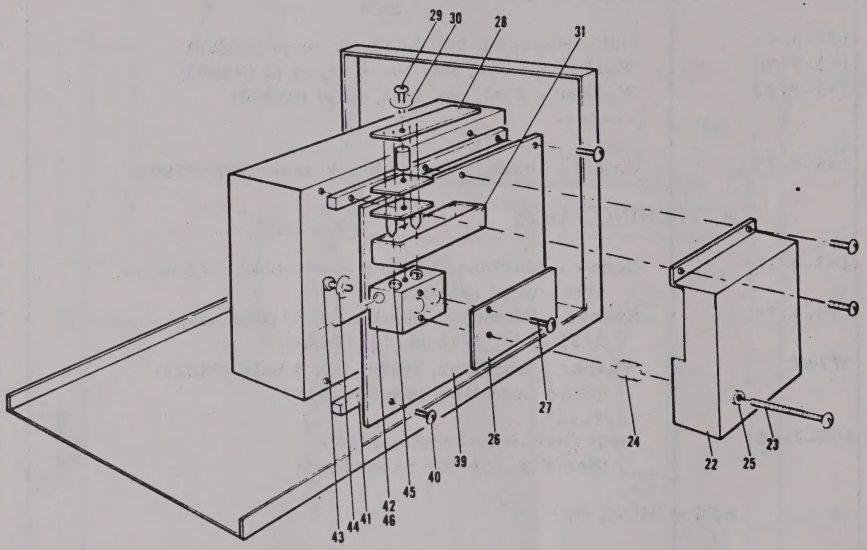


Fig. 6-3 Electronic Multimeter, 1604M (Page 3 of 3)

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y.	USAGE ON CODE
	GROUP		ELECTRONIC MULTIMETER, 1604M		
	MAJOR ASSEMBLY		ELECTRONIC MULTIMETER, 1604M (Cont'd)		
6-3					
-33		No Number	Panel - Front, assembly (95800) (See Fig. 6-8 for breakdown)	1	
			ATTACHING PARTS		
-34		143-4-6	Screw - Machine, flat head, 4-40, 1/4 in. lg., steel, ni pl (95800) ---*---	3	
-35		No Number	Panel - Rear, assembly (95800) (See Fig 6-11 for breakdown)	1	
			ATTACHING PARTS		
-36		143-4-6	Screw - Machine, flat head, 4-40, 1/4 in. lg. steel, ni pl (95800) ---*---	4	
-37		No Number	Chassis Assembly-Printed circuit board (95800)	1	
			ATTACHING PARTS		
-38		143-4-6	Screw - Machine, flat head, 4-40, 1/4 in. lg. steel, ni pl (95800) ---*---	4	
-39		152-2-8	Amplifier Assembly (95800) (See Fig. 6-12 for breakdown)	1	
			ATTACHING PARTS		
-40		143-4-113	Screw - Machine, binding head, 4-40, 1/2 in. lg. steel, ni pl (95800) ---*--	3	
-41		115-6-52	Standoff - Phenolic, 5 in. lg. x 3/8 in. x 1/4 in. (95800)	2	
-42		152-2-6	Chopper Block Assembly (95800)	1	
			ATTACHING PARTS		
-43		143-4-113	Screw - Machine, binding head, 4-40, 1/2 in. lg steel, ni pl (95800)	1	
-44		153-9-91	Washer - Lock, No. 4, internal, steel, ni pl (95800) ---*---	1	

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY / PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
		GROUP: ELECTRONIC MULTIMETER, 1604M MAJOR ASSEMBLY: ELECTRONIC MULTIMETER, 1604M (Cont'd)		
6-3-				
-45	145-5-84	Screen - Copper, 32 mesh, 0.0075 wire, 3/4 in. x 13/16 in. (95800)	2	
-46	104-1-83	Block - Chopper, aluminum, machined (95800)	1	
-47	2X15	Resistor - Fixed, wirewound, 15 ohms ± 10%, 2 watt (R4) (09746) (Spec Cont Dwg 184-35-150)	1	
-48	152-2-10	Calibration Board Assembly (95800) (See Fig. 6-13 for breakdown)	1	
		ATTACHING PARTS		
-49	143-4-113	Screw - Machine, binding head, 4-40, 1/2 in. lg. steel, ni pl (95800) ---*---	4	
-49A	109-2-7	Clamps-1/8 in. I.D. No. 6, vinylite, black	2	
-50	115-6-76	Standoff - Phenolic, 2 in. lg x 3/8 in. x 1/4 in.	2	
-51	152-2-11	Power Supply Assembly (95800) (See Fig. 6-14 for breakdown)	1	
		ATTACHING PARTS		
-52	143-4-113	Screw - Machine, binding head, 4-40, 1/2 in. lg. steel, ni pl (95800) ---*---	4	
-53	115-6-52	Standoff - Phenolic, 5 in. lg. x 3/8 in. x 1/4 in. (95800)	2	
-54	152-2-19	Chassis Assembly (95800)	1	
-55	1N1602	Semiconductor Device Diode - Zener 6.8 v, c/w mtg hardware, 2 mica washers, 1 teflon grommet, 1 flat washer, 1 solder lug, 1 nut (Z3) (35009) (Spec Cont Dwg 138-2-32)	1	
-56	1403	Grommet - Rubber, 1/4 in. id., 5/8 in. od. for 3/8 in. hole (72653) (Spec Cont Dwg 116-10-1)	2	
-57	No Number	Transformer - Power, primary: 115/230 vac, 50/1100 cps; secondary: 18v and 6.5v	1	

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
	GROUP		ELECTRONIC MULTIMETER, 1604M		
	MAJOR ASSEMBLY		ELECTRONIC MULTIMETER, 1604M (Cont'd)		
6-3					
-58		No Number	Transformer - Auxiliary power supply: primary: 115/230 vac, 50/1100 cps; secondary: for 300 vdc, 10 ma, full wave power supply (T2) (Spec Cont Dwg 148-9-122)	1	
			ATTACHING PARTS		
-59		143-6-7	Screw - Machine, rd hd, No. 6-32 1/4 in. lg. steel, ni pl (95800)	2	
-60		153-9-96	Washer - Lock, No. 6, internal star, steel, ni pl (95800)	2	
-61		127-6-9	Nut - Hexagon, No. 6-32, steel ni pl. (95800)	2	
			---*---		
-62		145-5-73	Chassis (95800)	1	
-63		No. 3-1/2	Bumper - Rubber (35388) (Spec Cont Dwg 116-1-38)	4	
			ATTACHING PARTS		
-64		143-6-7	Screw - Machine, rd hd, 6-32, 1/4 in. lg., steel, ni pl (95800)	1	
-65		153-2-23	Washer - Flat, No. 6, brass, ni pl (95800)	1	
			---*---		
-66		No Number	Cabinet - Bottom panel, painted (Part of Part No.107-9-83 (95800)	1	

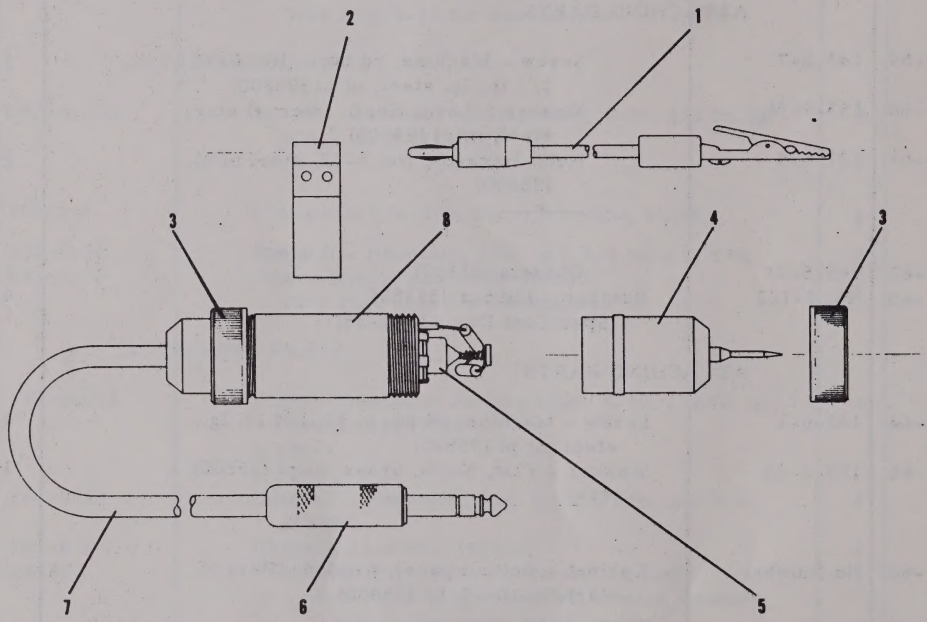


Fig. 6-4 Test Lead Assembly - AC Probe

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
	GROUP	ELECTRONIC MULTIMETER, 1604M			
	MAJOR ASSEMBLY	ELECTRONIC MULTIMETER, 1604M			
6-4		151-7-11	Lead Assembly - AC (95800)	Ref	
			(See figure 6-3, item 2 for NHA)		
1		151-7-25	Ground Lead Subassembly (95800)	1	
2		110-3-13	Clip-Ground (95800)	1	
3		139-2-34	Coupling (95800)	2	
4		152-2-28	Nose Assembly-Probe (95800)	1	
5		163-1-85	Diode-UHF, EA53 (95800)	1	
6		133-1-43	Plug (95800)	1	
7		190-1-86	Cable-3 ft. (95800)	1	
8		152-2-29	Housing-Probe	1	

Table of Parts
Fig. 6-5

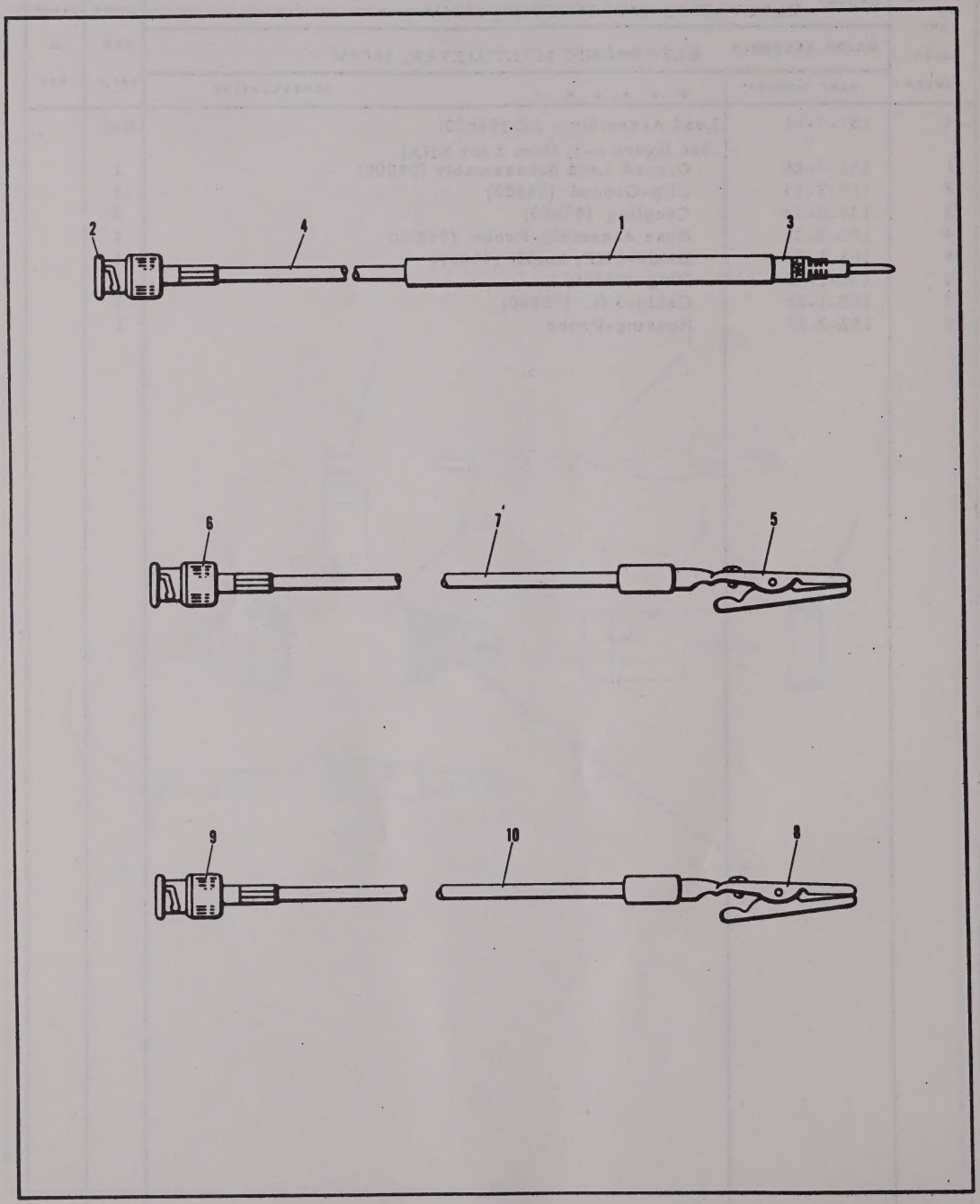


Fig. 6-5 Test Lead Assemblies

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
	GROUP		ELECTRONIC MULTIMETER, 1604M		
	MAJOR ASSEMBLY		TEST LEAD ASSEMBLIES		
6-5		151-7-12	Test Lead Assembly - DC Volts (95800) (See Fig. 6-3, item 3 for NHA)	Ref	
- 1		1841	Test Prod - Insulated, 4 in. red handle, c/w prod tip (94139) (Spec Cont Dwg 129-9-9)	1	
- 2		36775	Plug - BNC, quick-crimp type (P3) (03554) (Spec Cont Dwg 133-1-44)	1	
- 3		No Number	Resistor - Fixed, comp, 1 megohm ± 5%, 0.5 watt (R8) (12287) (Spec Cont Dwg 181-14-105)	1	
- 4		190-1-13	Cable - Coaxial RG58A/U, 3 ft. long (95800)	1	
		151-7-14	Test Lead Assembly - OHMS/DCA (95800) (See Fig. 6-3, item 4 for NHA)	Ref	
- 5		60HS	Clip - Alligator, insulated handle, red (76545) (Spec Cont Dwg 110-2-1)	1	
- 6		36775	Plug - BNC, quick-crimp type (P2) (03554) (Spec Cont Dwg 133-1-44)	1	
- 7		190-1-13	Cable Coaxial RG58A/U, 3 ft. long (95800)	1	
		151-7-13	Test Lead Assembly - COM (95800) (See Fig. 6-3, item 5 for NHA)	Ref	
- 8		60HS	Clip - Alligator, insulated handle, black (76545) (Spec Cont Dwg 110-3-1)	1	
- 9		36775	Plug - BNC, quick-crimp type (P1) (03554) (Spec Cont Dwg 133-1-44)	1	
-10		8401	Cable - Shielded, 3 ft. long (70903) (Spec Cont Dwg 190-1-15)	1	

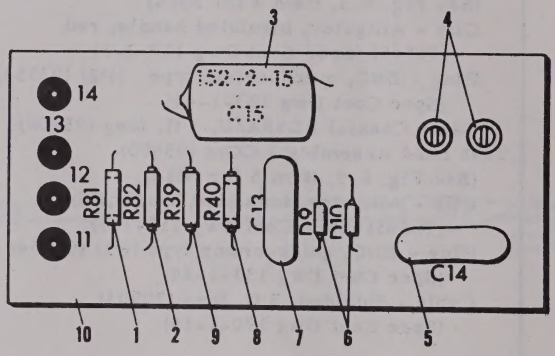


Fig. 6-6 Input Circuit Assembly, Part No. 152-2-15

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY / PART NUMBER	ELECTRONIC MULTIMETER, 1604M INPUT CIRCUIT ASSEMBLY 1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
6-6	152-2-15	Input Circuit Assembly (95800) (See Fig. 6-3, item 26 for NHA)	Ref	
- 1	Type C11 or Type M11	Resistor - Fixed, carbon dep, 649 ohms ± 1%, 0.25 watt (R81) (36002) (Spec Cont Dwg 164-7-86)	1	
- 2	Type C11 or Type M11	Resistor - Fixed, carbon dep, 100 ohms ± 1%, 0.25 watt (R82) (36002) (Spec Cont Dwg 182-92-101)	1	
- 3	CPR6200	Capacitor - Fixed, polystyrene, 6200 pf, 500 vdcw (C15) (71590) (Spec Cont Dwg 112-7-23)	1	
- 4	138-2-56	Photocell - Matched set (PH1, PH2) (95800)	1 PR	
- 5	PVC1168	Capacitor - Fixed, mylar, 0.068 µf, 100 vdcw (C14) (37942) (Spec Cont Dwg 112-7-14)	1	
- 6	1N457	Semiconductor Device Diode (D9, D10) (01295) (Spec Cont Dwg 138-2-29)	2	
- 7	PVC101	Capacitor - Fixed, mylar, 0.1 µf, 100 vdcw (C13) (37942) (Spec Cont Dwg 112-7-16)	1	
- 8	Type C11 or Type M11	Resistor - Fixed, carbon dep, 2.2 megohms ± 1%, 0.25 watt (R40) (36002) (Spec Cont Dwg 182-92-225)	1	
- 9	Type C11 or Type M11	Resistor - Fixed, carbon dep, 681 K ohms ± 1% 0.25 watt (R39) (36002) (Spec Cont Dwg 164-7-84)	1	
-10	115-6-67	Printed Circuit Board (95800)	1	

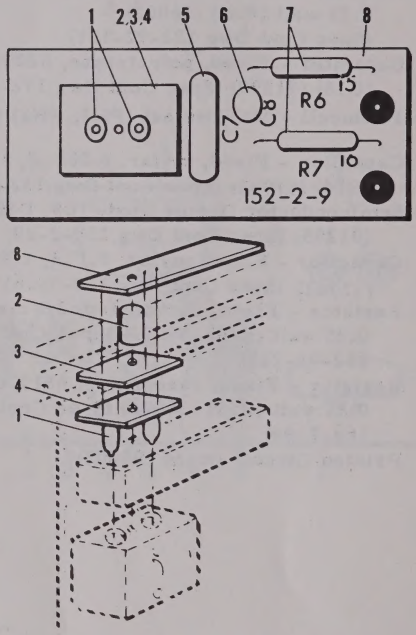


Fig. 6-7 Chopper Drive Assembly, Part No. 152-2-9

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
	GROUP		ELECTRONIC MULTIMETER, 1604M		
	MAJOR ASSEMBLY		CHOPPER DRIVE ASSEMBLY		
6-7		152-2-9	Chopper Drive Assembly (95800) (See Fig. 6-3, item 28 for NHA)	Ref	
- 1		125-09-019	Lamp - Neon (L3, L4) (95800)	1 Pr	
- 2		115-6-72	Spacer - Phenolic, 1/4 in. od, 1/8 in. id, 5/16 in. lg (95800)	1	
- 3		115-6-73	Pad - 1/16 in. thick, 1 in. x 3/4 in. black, phenolic (95800)	1	
- 4		115-6-74	Pad - Soft rubber, 1/16 in. thk, 3/4 in. x 1 in. (95800)	1	
- 5		PVC 1168	Capacitor - Fixed, mylar 0.068 µf (C7) (37942) (Spec Cont Dwg 112-7-14)	1	
- 6		DDM203	Capacitor - Fixed, ceramic disc, 0.02 µf, 150 vdcw (C8) (Selected during factory calibration) (71590) (Spec Cont Dwg 112-7-30)	1	
		DDM103	Capacitor - Fixed, ceramic disc, 0.01 µf 150 vdcw (Alternate) (Selected during factory calibration) (C8) (71590) (Spec Cont Dwg 112-7-36)	1	
- 7		Type F20	Resistor - Fixed, metal oxide, 100 K ohms ± 5%, 0.5 watt (R6, R7) (36002) (Spec Cont Dwg 185-14-104)	2	
- 8		115-6-56	Printed Circuit Board (95800)	1	

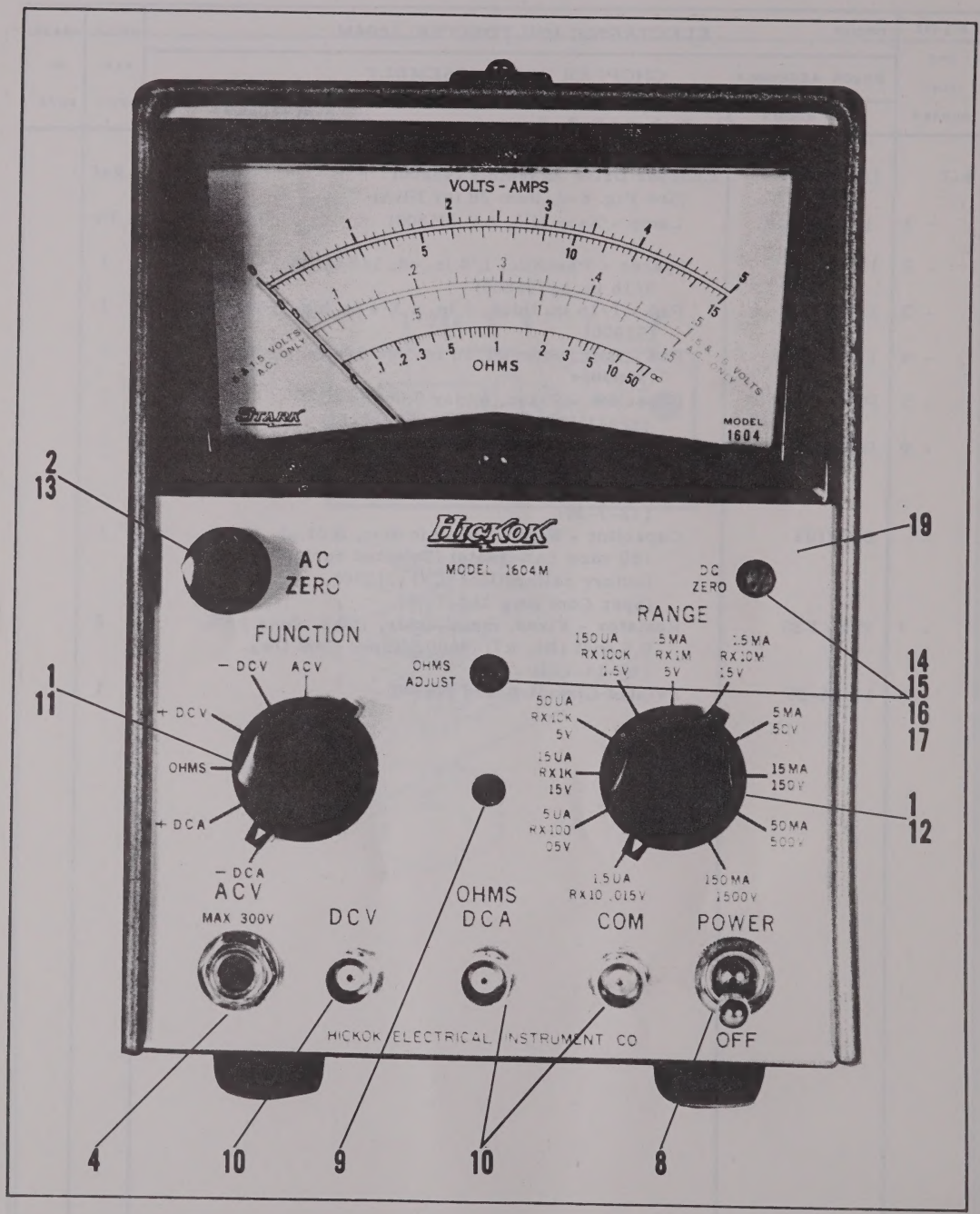


Fig. 6-8 Front Panel Assembly (Page 1 of 2)

FIGURE AND INDEX NUMBER	PART NUMBER	GROUP: ELECTRONIC MULTIMETER, 1604M MAJOR ASSEMBLY: FRONT PANEL ASSEMBLY 1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
6-8	No Number	Front Panel Assembly (95800) (See Fig. 6-3, item 33 for NHA)	Ref	
- 1	No. 7	Knob - Bar type, FUNCTION and RANGE switches (95800) (Spec Cont Dwg 121-4-34)	2	
- 2	No. 5	Knob - Cap type, AC ZERO (95800) (Spec Cont Dwg 121-4-35)	1	
- 3	Type 858	Capacitor - Fixed, ceramic disc, 3300 µf ± 10% 1000 vdcw (C12) (12294) (Spec Cont Dwg 112-7-20)	1	
- 4	No. 12B	Jack - 3 conductor, 'Litteljax' (J4) (82389) (Spec Cont Dwg 130-10-7)	1	
- 5	2440-20	Lug - Terminal (78189) (Spec Cont Dwg 147-9-60)	1	
- 6	153-2-7	Washer - Shoulder, fibre, 3/4 od. x 3/8 id x 1/32 in. shoulder, 1/2 in. flange (95800)	1	
- 7	153-1-13	Washer - Flat, fibre, 5/8 od x 3/8 id x 1/16 in. thk	1	
- 8	36005	Switch - POWER, Toggle, SPST (SW1) (Castelco) (Spec Cont Dwg 144-12-10)	1	
- 9	300-RD-HM642	Lamp Assy - Indicator, red (PL1) (Spec Cont Dwg 126-3-11)	1	
-10	31-221	Receptacle - BNC, Bulkhead, COM, OHMS/DCA, DCV (J1, J2, J3) (03554) (Spec Cont Dwg 130-1-15)	1 3	
-11	152-2-16	Switch Assembly - FUNCTION, c/w mtg hardware (95800) (See Fig. 6-9 for breakdown)		
-12	152-2-7	Switch Assembly - RANGE, c/w mtg hardware (95800) (See Fig.6-10 for breakdown)	1	
-13	Type AW	Potentiometer - Wire wound, AC ZERO 10 K ohms ± 10%, Linear, 3-5 watt, c/w mtg hardware (R37) (11236) (Spec Cont Dwg 134-6-38)	1 1	
-14	Type 117	Potentiometer - Wire wound, 1 K ohm ± 10% linear, 2-3 watts, OHMS ADJUST and DC ZERO (R35, R61) (11236) (Spec Cont Dwg 134-6-39)	1	
		ATTACHING PARTS	2	
-15	143-4-6	Screw - Machine, flat head, No. 4-40, 1/4 in. lg. steel, ni pl (95800)		
-16	153-9-91	Washer - Lock, internal, No. 4, steel, ni pl. (95800)		
-17	127-4-7	Nut - Hexagon, No. 4-40, steel, ni pl (95800) ---*---	2	
-18	104-1-82	Bracket - Potentiometer holder, 0.062 in. thk alum.(95800)	2 2	
-19	128-9-132	Panel - Front 0.062 in. alum., etched and machined (95800)	1	

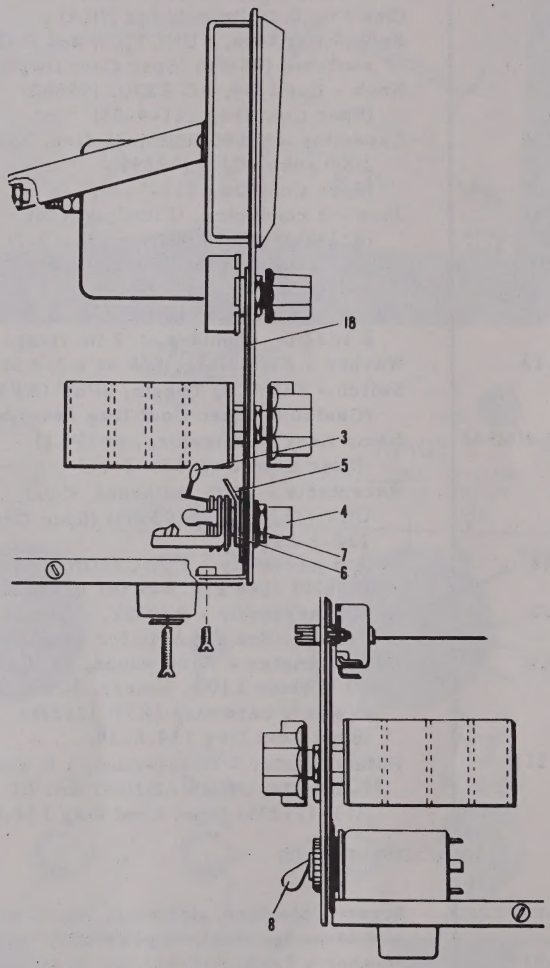


Fig. 6-8 Front Panel Assembly (Page 2 of 2)

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE

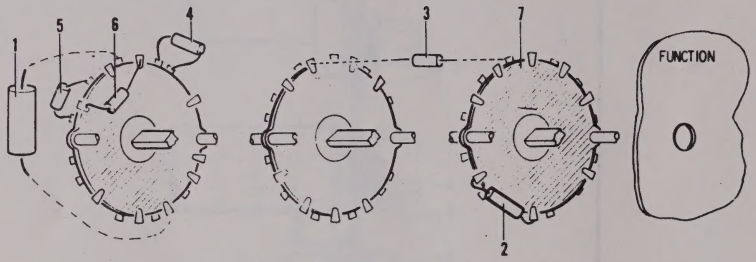


Fig. 6-9 FUNCTION Switch Assembly, Part No. 152-2-16

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
	GROUP	ELECTRONIC MULTIMETER, 1604M			
	MAJOR ASSEMBLY	FUNCTION SWITCH ASSEMBLY			
6-9		152-2-16	Switch Assembly - FUNCTION (95800) (See Fig. 6-8, item 12 for NHA)	Ref	
- 1		Type NS	Resistor - Fixed, carbon dep, 60 megohms ±10%, 1 watt (R38) (35929) (Spec Cont Dwg 182-25-606)	1	
- 2		2X160	Resistor - Fixed, wirewound, 160 ohms, 2 watt (R68) (09746) (Spec Cont Dwg 184-35-161)	1	
- 3		Type C11 or Type M11	Resistor - Fixed, carbon dep, 150 ohms ± 1% 0.25 watt (R70) (36002) (Spec Cont Dwg 182-92-151)	1	
- 4		No Number	Resistor - Fixed, carbon comp, 10 ohms ±5% 1 watt (R11) (12287) (Spec Cont Dwg 181-24-100)	1	
- 5		No Number	Resistor - Fixed, carbon comp, 0 to 1M ±5 or 10%, 0.5 watt, (value to be determined during factory calibration) (R12)	1	
- 6		Type F20	Resistor - Fixed, metal oxide, 120 K ohms ±5%, 0.5 watt (R36) (36002) (Spec Cont Dwg 185-14-124)	1	
- 7		144-5-44	Switch - Rotary, ceramic, 3 section, 6 position FUNCTION (95800)	1	

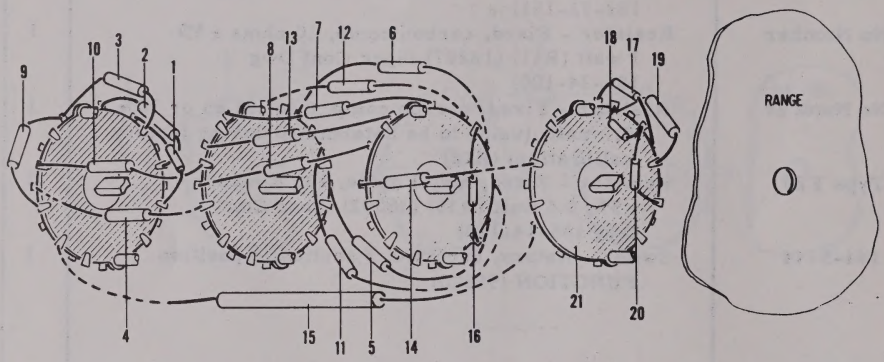


Fig. 6-10 RANGE Switch Assembly, Part No. 152-2-7

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY / PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
	GROUP	ELECTRONIC MULTIMETER, 1604M		
	MAJOR ASSEMBLY	RANGE SWITCH ASSEMBLY		
6-10	152-2-7	Switch Assembly - RANGE (95800) (See Fig. 6-8, item 13 for NHA)	Ref	
- 1	Type A20	Resistor - Fixed, carbon dep, precision, 2 ohms ±0.5%, 0.5 watt (R27) (36002) (Spec Cont Dwg 164-7-96)	1	
- 2	Type C12 or Type M12	Resistor - Fixed, carbon dep, precision, 7 ohms ±0.5%, 0.5 watt (R26) (36002) (Spec Cont Dwg 182-11-070)	1	
- 3	Type C12 or Type M12	Resistor - Fixed, carbon dep, precision, 20 ohms ±0.5%, 0.5 watt (R25) (36002) (Spec Cont Dwg 182-11-200)	1	
- 4	Type C12 or Type M12	Resistor - Fixed, carbon dep, precision, 200 ohms ±0.5%, 0.5 watt (R23) (36002) (Spec Cont Dwg 182-11-201)	1	
- 5	Type C12 or Type M12	Resistor - Fixed, carbon dep, precision, 2 K ohms ±0.5%, 0.5 watt (R21) (36002) (Spec Cont Dwg 182-11-202)	1	
- 6	Type C12 or Type M12	Resistor - Fixed, carbon dep, precision, 20 K ohms ±0.5%, 0.5 watt (R19) (36002) (Spec Cont Dwg 182-11-203)	1	
- 7	Type C12 or Type M12	Resistor - Fixed, carbon dep, precision, 200 K ohms ±0.5%, 0.5 watt (R17) (36002) (Spec Cont Dwg 182-11-204)	1	
- 8	Type C12 or Type M12	Resistor - Fixed, carbon dep, precision, 2 megohms ±0.5%, 0.5 watt (R15) (36002) (Spec Cont Dwg 182-11-205)	1	
- 9	Type C12 or Type M12	Resistor - Fixed, carbon dep, precision, 70 ohms ±0.5%, 0.5 watt (R24) (36002) (Spec Cont Dwg 182-11-700)	1	
-10	Type C12 or Type M12	Resistor - Fixed, carbon dep, precision, 700 ohms ±0.5%, 0.5 watt (R22) (36002) (Spec Cont Dwg 182-11-701)	1	
-11	Type C12 or Type M12	Resistor - Fixed, carbon dep, precision, 7 K ohms ±0.5%, 0.5 watt (R20) (36002) (Spec Cont Dwg 182-11-702)	1	
-12	Type C12 or Type M12	Resistor - Fixed, carbon dep, precision, 70 K ohms ±0.5%, 0.5 watt (R18) (36002) (Spec Cont Dwg 182-11-703)	1	
-13	Type C12 or Type M12	Resistor - Fixed, carbon dep, precision, 700 K ohms ±0.5%, 0.5 watt (R16) (36002) (Spec Cont Dwg 182-11-704)	1	
-14	Type C12 or Type M12	Resistor - Fixed, carbon dep, precision, 6 megohms ±0.5%, 0.5 watt (R14) (36002) (Spec Cont Dwg 182-11-605)	1	

Table of Parts
Fig. 6-10

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
	GROUP	ELECTRONIC MULTIMETER, 1604M			
	MAJOR ASSEMBLY	RANGE SWITCH ASSEMBLY			
6-10					
-15		89M	Resistor - Fixed, metal film, 89 megohms ± 1%, 2 watt (R13) (36002) (Spec Cont Dwg 164-7-95)	1	
-16		Type C11 or Type M11	Resistor - Fixed, carbon dep, 2.2 megohms ± 1%, 0.25 watt (R31) (36002) (Spec Cont Dwg 182-92-225)	1	
-17		Type C11 or Type M11	Resistor - Fixed, carbon dep, 10 megohms ± 1%, 0.25 watt (R76) (36002) (Spec Cont Dwg 182-92-100)	1	
-18		Type C11 or Type M11	Resistor - Fixed, carbon dep, 100 ohms ± 1%, 0.25 watt (R33) (36002) (Spec Cont Dwg 182-92-101)	1	
-19		Type C11 or Type M11	Resistor - Fixed, carbon dep, 33 ohms ± 1%, 0.25 watt (R32) (36002) (Spec Cont Dwg 182-92-330)	1	
-20		Type C11 or Type M11	Resistor - Fixed, carbon dep, 3.6 K ohms ± 1%, 0.25 watt (R34) (36002) (Spec Cont Dwg 182-92-362)	1	
-21		No Number	Switch - Rotary, ceramic, 4 section, 11 position RANGE (95800) (Spec Cont Dwg 144-5-45)	1	
				1	

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE

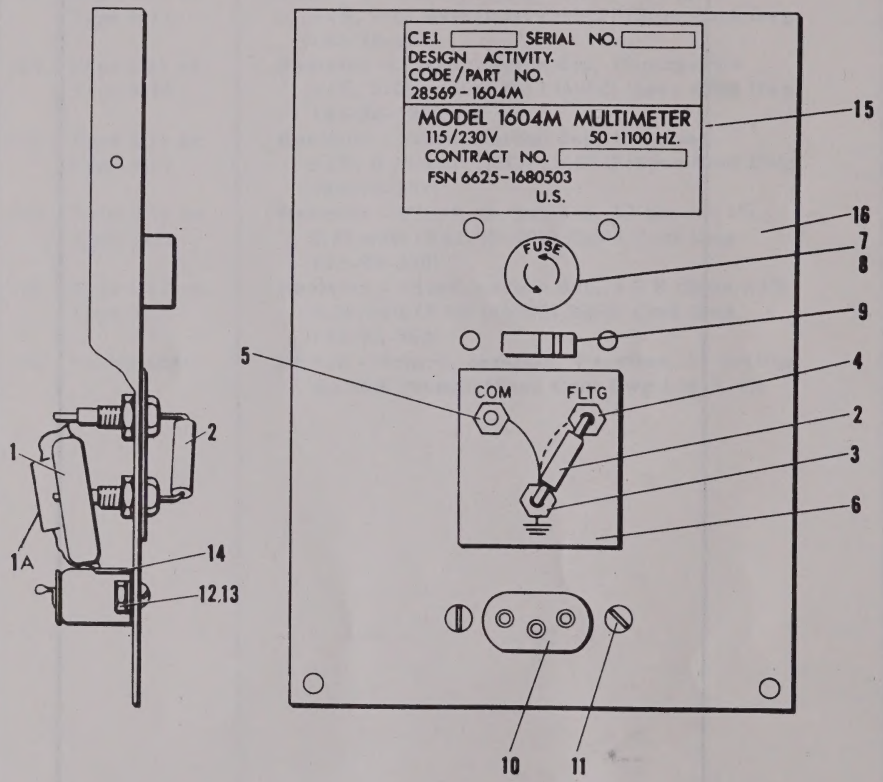


Fig. 6-11 Rear Panel Assembly

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY / PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
	GROUP	ELECTRONIC MULTIMETER, 1604M		
	MAJOR ASSEMBLY	REAR PANEL ASSEMBLY		
6-11	No Number	Panel - Rear, Assembly (95800) (See Fig. 6-3, item 35 for NHA)	Ref	
- 1	PVC401	Capacitor - Fixed, mylar, 0.1 µf, 400 vdcw (C1) (37942) (Spec Cont Dwg 112-7-19)	1	
-1A	No Number	Resistor - Fixed, carbon comp, 10M ohms ± 10%, 0.5 watts (R85) (12287) (Spec Cont Dwg 181-15-106)	1	
- 2	133-1-42	Plug - Grounding, c/w insulated handle (95800)	1	
- 3	119605A	Jack - Pin, white, c/w mtg nut (78947) (Spec Cont Dwg 132-1-16)	1	
- 4	119605B	Jack - Pin, red, c/w mtg nut (78947) (Spec Cont Dwg 132-1-17)	1	
- 5	119605C	Jack - Pin, black, c/w mtg nut (78947) (Spec Cont Dwg 132-1-18)	1	
- 6	123-3-64	Plate - Marker, aluminum, 0.062 in. thk silver satin finish, black filled etch (95800)	1	
- 7	312-250	Fuse - 0.25A, 3AG (F1) (75915) (Spec Cont Dwg 125-9-11)	1	
- 8	342001	Fuseholder - (75915) (Spec Cont Dwg 110-03-008)	1	
- 9	G326	Switch - Slide, DPDT (SW2) (79727) (Spec Cont Dwg 144-9-120)	1	
-10	VH1061	Connector - Receptacle, electrical, recessed, input power, three conductor (87930) (Spec Cont Dwg 140-6-20)	2 2	
		ATTACHING PARTS	2	
-11	143-6-7	Screw - Machine, rd hd, 6-32, 1/4 in. lg. steel, ni pl (95800)	1	
-12	153-9-96	Washer - Lock, int. No. 6, steel, ni pl. (95800)	1	
-13	127-6-9	Nut - Hexagon, No. 6-32, steel, ni pl (95800)	1	
		---*---		
-14	2102-14-00	Lug - Terminal, 1/4 in. (78189) (Spec Cont Dwg 147-1-13)	1	
-15	123-03-087	Nameplate - Hickok (95800)	1	
-16	No Number	Panel - Rear, painted (P/O Part No. 107-9-67) (95800)	1	

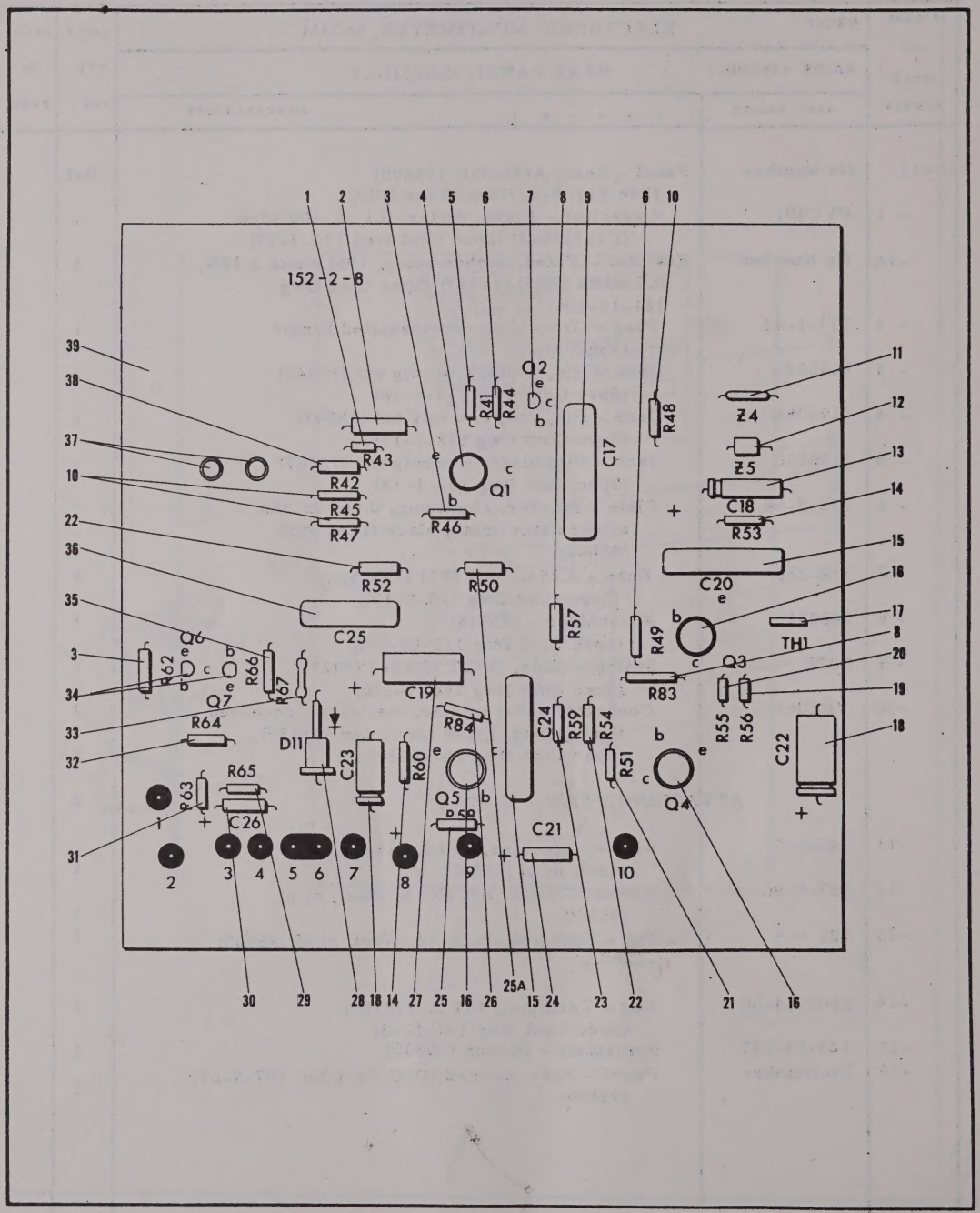


Fig. 6-12 Amplifier Assembly, Part No. 152-2-8

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	ELECTRONIC MULTIMETER, 1604M / AMPLIFIER ASSEMBLY	UNITS PER ASS'Y	USAGE ON CODE
	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE		
6-12	152-2-8	Amplifier Assembly (95800) (See Fig. 6-3, item 39 for NHA)	Ref	
- 1	No Number	Resistor - Fixed, carbon comp, 1 megohm ±5%, 0.5 watts (R43) (12287) (Spec Cont Dwg 181-14-105)	1	
- 2	TT6X1	Capacitor - Fixed, electrolytic, 1 µf, 6 vdcw (C16) (37942) (Spec Cont Dwg 112-7-9)	1	
- 3	No Number	Resistor - Fixed, carbon comp, 39 K ohms ± 5%, 0.5 watts (R46, R62) (12287) (Spec Cont Dwg 181-14-393)	2	
- 4	2N3820	Transistor (Q1) (01295) (Spec Cont Dwg 162-1-19)	1	
- 5	No Number	Resistor - Fixed, carbon comp, XXX ±5% or 10% 0.5 watt (Value between 330 K ohms and 700 K ohms selected during factory calibration) (R41) (12287) (Spec Cont Dwg. 181)	1	
- 6	Type F-20	Resistor - Fixed, metal oxide, 18 K ohms ± 5%, 0.5 watt (R44, R49) (12287) (Spec Cont Dwg 185-14-183)	2	
- 7	2N3708	Transistor (Q2) (01295) (Spec Cont Dwg 162-1-15)	1	
- 8	No Number	Resistor - Fixed, carbon comp, 56 K ohms ± 5%, 0.5 watt (R57, R83) (12287) (Spec Cont Dwg 181-14-563)	2	
- 9	PVC1033	Capacitor - Fixed, mylar, 0.33 µf, 100 vdcw (C17) (37942) (Spec Cont Dwg 112-7-18)	1	
-10	Type F-20	Resistor - Fixed, metal oxide, 22 K ohms ± 5%, 0.5 watt (R45, R47, R48) (12287) (Spec Cont Dwg 185-14-223)	3	
-11	BYZ58	Semiconductor Device Diode - zener, 5.6v (Z4) (36204) (Spec Cont Dwg 138-2-28)	1	
-12	VR14	Semiconductor Device Diode - zener, 14 v, 10%, (Z5) (84970) (Spec Cont Dwg 138-2-34)	1	
-13	TT15X30	Capacitor - Fixed, electrolytic, 30 µf, 15 vdcw, (C18) (37942) (Spec Cont Dwg 112-7-10)	1	
-14	No Number	Resistor - Fixed, carbon comp, 1.6 K ohms ± 5%, 0.5 watt (R53, R60) (12287) (Spec Cont Dwg 181-14-162)	2	
-15	PVC1025	Capacitor - Fixed, mylar, 0.25 µf, 100 vdcw, (C20, C24) (37942) (Spec Cont Dwg 112-7-15)	2	
-16	2N1377	Transistor (Q3, Q4, Q5) (01295) (Spec Cont Dwg 162-1-14)	3	
-17	B83200LA/1K3	Thermistor - 1 K ohms, 10%, (TH1) (36204) (Spec Cont Dwg 171-1-2)	1	
-18	TT6X75	Capacitor - Fixed, electrolytic, 75 µf, 6 vdcw (C22, C23) (37942) (Spec Cont Dwg 112-7-11)	2	

Table of Parts
Fig. 6-12

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY: ELECTRONIC MULTIMETER, 1604M / AMPLIFIER ASSEMBLY (Cont'd)		UNITS PER ASS'Y	USAGE ON CODE
	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE		
6-12				
-19	No Number	Resistor - Fixed, carbon comp, 1.2 K ohms ± 5%, 0.5 watt (R56) (12287) (Spec Cont Dwg 181-14-122)	1	
-20	No Number	Resistor - Fixed, carbon comp, 180 ohms ± 5%, 0.5 watt (R55) (12287) (Spec Cont Dwg 181-14-181)	1	
-21	No Number	Resistor - Fixed, carbon comp, 430 ohms ± 5%, 0.5 watt (R51) (12287) (Spec Cont Dwg 181-14-431)	1	
-22	No Number	Resistor - Fixed, carbon comp, 4.7 K ohms ± 5%, 0.5 watt (R52, R54) (12287) (Spec Cont Dwg 181-14-472)	2	
-23	No Number	Resistor - Fixed, carbon comp, 8.2 K ohms ± 5%, 0.5 watt (R59) (12287) (Spec Cont Dwg 181-14-822)	1	
-24	CS13 A1-FBR9K	Capacitor - Fixed, tantalum, electrolytic 3.9 µf, 35 vdcw (C21) (37942) (Spec Cont Dwg 112-7-34)	1	
-25	No Number	Resistor - Fixed, carbon comp, 6.8 K ohms ± 5%, 0.5 watt (R58) (12287) (Spec Cont Dwg 181-14-682)	1	
-25A	No Number	Resistor - Fixed, carbon comp, 10K ohms ± 5%, 0.5 watt (R50) (12287) (Spec Cont Dwg 181-14-103)	1	
-26	No Number	Resistor - Fixed, carbon comp, 56 ohms ± 5%, 0.5 watt (R84) (12287) (Spec Cont Dwg 181-14-560)	1	
-27	CS13 AD 151M	Capacitor - Fixed, tantalum, electrolytic, 150 µf, 15 vdcw (C19) (37942) (Spec Cont Dwg 112-7-35)	1	
-28	No Number	Semiconductor Device Diode - Rectifier (D11) (95800) (Spec Cont Dwg 138-2-30)	1	
-29	No Number	Resistor - Fixed, carbon comp, 470 ohms ± 5%, 0.5 watt (R65) (12287) (Spec Cont Dwg 181-14-471)	1	
-30	DE409	Capacitor - Fixed, tantalum electrolytic, 10 µf ± 10%, 20 vdcw (C26) (37942) (Spec Cont Dwg 112-7-12)	1	
-31	No Number	Resistor - Fixed, carbon comp, 220 K ohms ± 5%, 0.5 watt (R63) (12287) (Spec Cont Dwg 181-14-224)	1	
-32	No Number	Resistor - Fixed, carbon comp, 1.5 meg ± 5%, 0.5 watt (R64) (12287) (Spec Cont Dwg 181-14-155)	1	
-33	Type C11 or Type M11	Resistor - Fixed, carbon comp, 500 ohms ± 1%, 0.25 watt (R67) (36002) (Spec Cont Dwg 182-92-501)	1	
-34	2N3711	Transistor (Q6, Q7) (01295) (Spec Cont Dwg 162-1-12)	2	

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
	GROUP		ELECTRONIC MULTIMETER, 1604M		
	MAJOR ASSEMBLY		AMPLIFIER ASSEMBLY (Cont'd)		
6-12					
-35		No Number	Resistor - Fixed, carbon comp, 10 K ohms ± 5%, 0.5 watt (R66) (12287) (Spec Cont Dwg 181-14-103)	1	
-36		PVC1168	Capacitor - Fixed, mylar, 0.068 µf, 100 vdcw (C25) (37942) (Spec Cont Dwg 112-7-14)	1	
-37		128-2-57	Photocell - Matched set (PH3, PH4) (95800)	1 PR	
-38		Type F-20	Resistor - Fixed, metal oxide, 150 K ohms ± 5%, 0.5 watt (R42) (36002) (Spec Cont Dwg 185-14-154)	1	
-39		115-6-55	Printed Circuit Board Assembly (95800)	1	

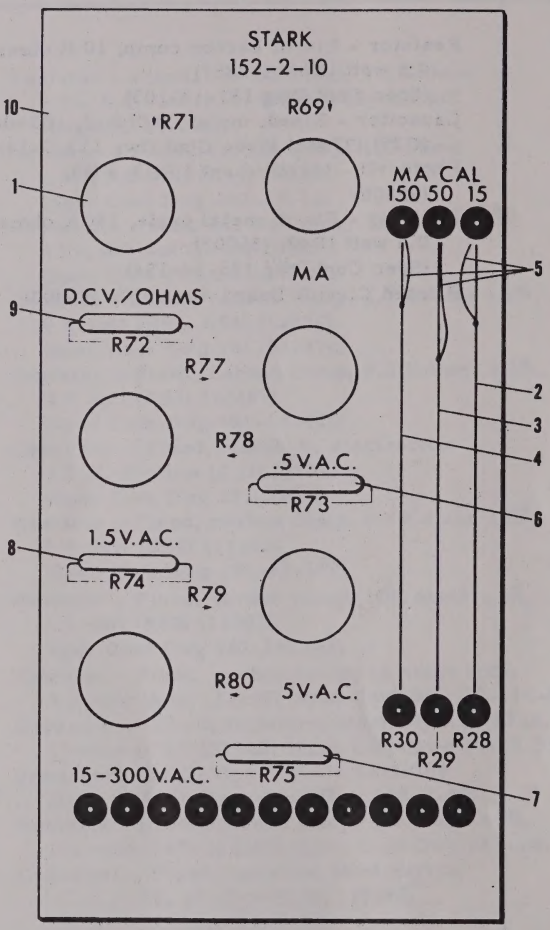


Fig. 6-13 Calibration Board Assembly, Part No. 152-2-10

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	ELECTRONIC MULTIMETER, 1604M / CALIBRATION BOARD ASSEMBLY	UNITS PER ASS'Y	USAGE ON CODE
	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE		
6-13	152-2-10	Calibration Board Assembly (95800) (See Fig. 6-3, item 48 for NHA)	Ref	
- 1	115-PC	Potentiometer - Wirewound, 300 ohms, 3 watt (R69, R71, R77, R78, R79, R80) (11236) (Spec Cont Dwg 134-6-40)	6	
- 2	164-9-34	Wire - Resistance, Manganin No. 32, 0.7 ohm 3 in. lg (R28) (95800)	1	
- 3	164-9-35	Wire - Resistance, Manganin No. 26, 0.2 ohm 3 in. lg (R29) (95800)	1	
- 4	164-9-36	Wire - Resistance, Manganin No. 22, 0.1 ohm 3 in. lg (R30) (95800)	1	
- 5	191-24-120	Wire - Copper, No. 24, tinned, 1 in. lg (95800)	AR	
- 6	Type C11 or Type M11	Resistor - Fixed, carbon dep, 500 ohms ± 1%, 0.25 watt (R73) (36002) (Spec Cont Dwg 182-92-501)	1	
- 7	Type C11 or Type M11	Resistor - Fixed, carbon dep, 120 ohms ± 1%, 0.25 watt (R75) (36002) (Spec Cont Dwg 182-92-121)	1	
- 8	Type C11 or Type M11	Resistor - Fixed, carbon dep, 180 ohms ± 1%, 0.25 watt (R74) (36002) (Spec Cont Dwg 182-92-181)	1	
- 9	Type C11 or Type M11	Resistor - Fixed, carbon dep, 10 ohms ± 1%, 0.25 watt (R72) (36002) (Spec Cont Dwg 182-92-100)	1	
-10	115-6-57	Printed Circuit Board (95800)	1	

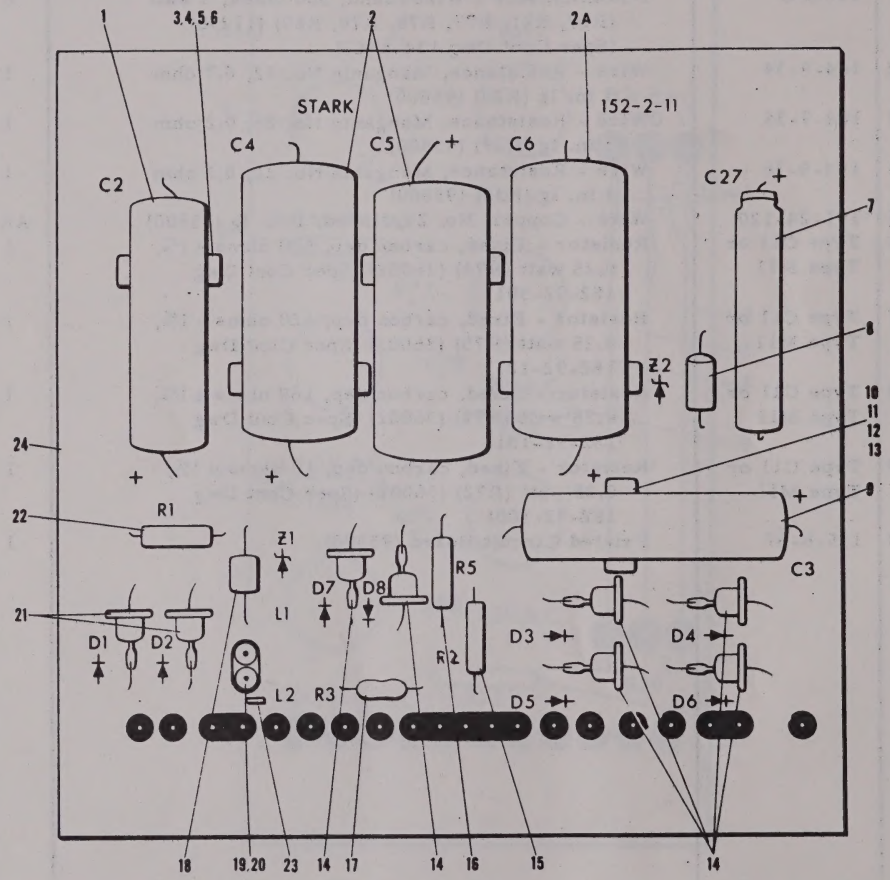
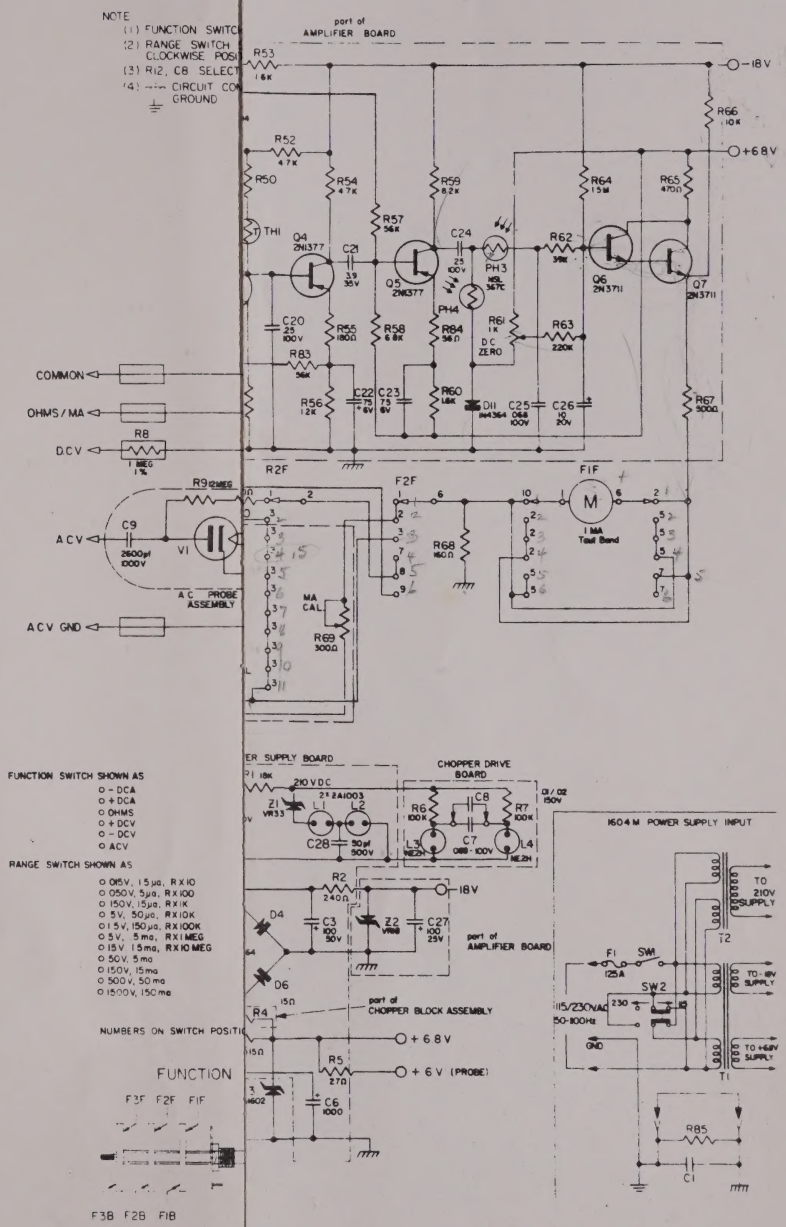


Fig. 6-14 Power Supply Assembly, Part No. 152-2-11

FIGURE AND INDEX NUMBER	GROUP / MAJOR ASSEMBLY	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y.	USAGE ON CODE
	GROUP	ELECTRONIC MULTIMETER, 1604M		
	MAJOR ASSEMBLY	POWER SUPPLY ASSEMBLY		
	PART NUMBER			
6-14	152-2-11	Power Supply Assembly (95800) (See Fig. 6-3, item 51 for NHA)	Ref	
- 1	TC64	Capacitor - Electrolytic, 16 µf, 350 vdcw (C2) (37942) (Spec Cont Dwg 112-7-8)	1	
- 2	TC610	Capacitor - Electrolytic, 1000 µf, 6 vdcw (C4, C5,) (37942) (Spec Cont Dwg 112-7-22)	2	
-2A	TVA-1211	Capacitor - Electrolytic, 1000µf, 25 vdcw (C6) (56289) (Spec cont dwg 112-12-117)	1	
		ATTACHING PARTS		
- 3	TH19	Clip - Capacitor, 7/8 in. (37942) (Spec Cont Dwg 110-3-16)	1	
- 4	143-4-3	Screw - Machine, flat head, 4-40, 1/4 in. lg steel, ni. pl. (95800)	1	
- 5	153-9-91	Washer - Lock, int. No. 4, steel, ni. pl.(95800)	1	
- 6	127-4-7	Nut - Hexagon, No. 4-40, steel, ni.pl. (95800) ---*---	1	
- 7	TT25X100	Capacitor - Electrolytic, 100 µf, 25 vdcw (C27) (37942) (Spec Cont Dwg 112-7-33)	1	
- 8	VR18	Semiconductor Device Diode - Zener, 18 v , 10%, (Z2) (84970) (Spec Cont Dwg 138-2-31)	1	
- 9	TC3501	Capacitor - Electrolytic, 100 µf, 50 vdcw (C3) (37942) (Spec Cont Dwg 112-7-21)	1	
		ATTACHING PARTS		
-10	TH17	Clip - Capacitor, 5/8 in. (37942) (Spec Cont Dwg 110-3-15)	1	
-11	143-4-3	Screw - Machine, flat head, No. 4-40, 1/4 in. lg, steel, ni. pl.	1	
-12	153-9-91	Washer - Lock, int. No. 4, steel, ni.pl.	1	
-13	127-4-7	Nut - Hexagon, No. 4-40, steel, ni. pl. ---*---	1	
-14	No Number	Semiconductor Device Diode - Rectifier (D1, D2, D3, D4, D5, D6, D7, D8) (01295) (Spec Cont Dwg. 138-2-19)	8	
-15	RC20GF241J	Resistor - Fixed, carbon comp, 240 ohms ± 5%, 0.5 watt (R2) (81349) (Spec Cont Dwg 181-14-241)	1	
-16	RC20GF2R7J	Resistor - Fixed, carbon comp, 2.7 ohms ± 5%, 0.5 watt (R5) (81349) (Spec Cont Dwg 181-14-027)	1	
-17	2X15	Resistor - Fixed, wirewound, 15 ohms ± 10%, 2 watt (R3) (09746) (Spec Cont Dwg 184-35-150)	1	

FIGURE AND INDEX NUMBER	PART NUMBER	1 2 3 4 5 6 7 NOMENCLATURE	UNITS PER ASS'Y	USAGE ON CODE
	GROUP	ELECTRONIC MULTIMETER, 1604M		
	MAJOR ASSEMBLY	POWER SUPPLY ASSEMBLY (Cont'd)		
6-14				
-18	VR33	Semiconductor Device Diode - Zener, 33 v, 10% (Z1) (84970) (Spec Cont Dwg 138-2-38)	1	
-19	ZA1003	Tube - Regulator, neon (L1, L2) (35784) (Spec Cont Dwg 163-1-86)	2	
-20	149-9-15	Sleeve - Clear, 3/8 in. dia, 3 - 1/2 in. lg (95800)	1	
-21	RC20GF183J	Resistor - Fixed, comp, 18 K ohms ±5%, 0.5 watt (R1) (81349) (Spec Cont Dwg 181-14-183)	1	
-22	DD500	Capacitor - Fixed, ceramic disc 50 pf, 500 vdcw (C28) (71590) (Spec Cont Dwg 112-7-42)	1	
-23	115-6-58	Printed Circuit Board (95800)	1	

PART 7
ILLUSTRATIONS



ter, ME-5012/U, Schematic Diagram

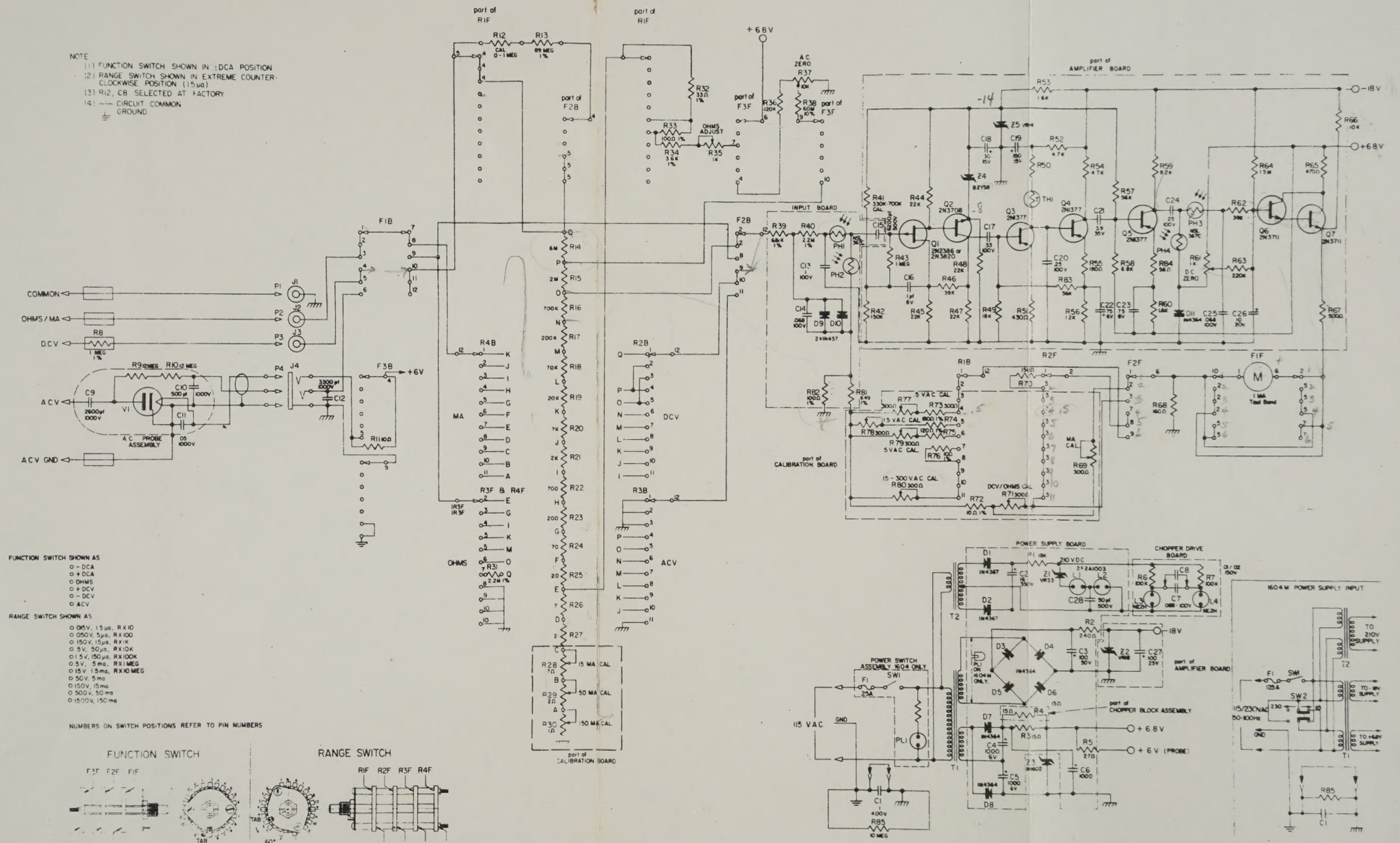


Fig. 7-1 Electronic Multimeter, ME-5012/U, Schematic Diagram